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Dr. James F. Norris has been consulting editor of the series since 1928. Dr. Louis P. Hammett became joint consulting editor in January, 1940.

CHEMICAL PUBLICATIONS

Their Nature and Use

BY

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SECOND EDITION

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THE CHEMICAL LITERATURE

(With apologies to Kipling)

The Literature,

The chemical literature—

When in doubt look it up in the literature.

Every question that man can raise, every phrase of every phase of that question is on record

In the literature;

Thrashed out threadbare pro and con

In the literature.

Did the universe at large once carry a positive charge?

Why aren't the holes in macaroni square?

From Avogadro's number to the analysis of cucumber, if you're interested you'll find it, for it's there

In the literature.

In *Journal* this or *Zeitschrift* that, *Comptes rendus* or *Zentralblatt*,

It's somewhere

In the literature.

—P. G. Horton

The experts are not to be ignored. On the contrary, they are to be earnestly heard and sedulously and gaily doubted. Those who ignore the past are doomed to repeat it. To heed the past and to doubt its deliverances is a *sine qua non* to not repeating it. Such doubt is creative since without it no way is opened to the innovation, discovery or invention to which mere repetition is the alternative.

PREFACE TO THE SECOND EDITION

During the decade since the appearance of the first edition of this book there has been a greater accumulation of chemical information than in any other equal period. In preparing a revised edition the primary objective has been to incorporate the changes necessitated by this new material.

Since no serious criticism of the adopted outline of publications has been presented, and since no proposal having more merit has been suggested, this classification has been retained in substantially its original form. No new publications essentially different in nature have appeared in the last ten years.

Many minor changes have been made in the descriptive material. Most of these include the addition of new publications, the substitution of a few new ones for some now considered less important, and the omission of a few now out of date. For all publications an attempt has been made to bring the data up to date.

As some users of the book have wanted material not included before, the field covered has been extended somewhat. Limitations of space prevented a more comprehensive compilation. The additions are chiefly in agricultural chemistry, biochemistry, metallurgy, physics, and engineering. The last two subjects have been restricted largely to the Appendix.

In the author's teaching most emphasis is placed on the library problems. The wear on a library caused by large classes presents a real administrative problem, yet actual contact with the publications seems practically indispensable for familiarizing students with such material. For experience in this part of the work the previous problems have been extensively revised. To save space only twenty assignments have been included as representative of those used for each part. The author posts, on 4- by 6-inch cards, enough assignments to provide a different one for each member of the class. If teachers who adopt this

book as a text are interested, he will be glad to consider arrangements for sharing his problems collected for large classes.

In this edition, as in the first, the author is greatly indebted to numerous persons for many facts and ideas. Dr. E. J. Crane, editor of *Chemical Abstracts*, supplied valuable information; many of the assistant editors of this journal checked, for their respective divisions, the list of periodicals given in Chap. II; the directors of the various governmental laboratories cited checked the description of the activities mentioned. The photographs included were furnished by the organizations represented. To all the individuals mentioned, and to the many others who cooperated so graciously in providing information, the author hereby expresses his appreciation.

M. G. MELLON.

LAFAYETTE, INDIANA,
March, 1940.

PREFACE TO THE FIRST EDITION

The records of known chemical facts, and the theoretical discussions involving them, even when limited to those recorded in the century and a half since the fundamental discoveries of Lavoisier, present an impressive collection as viewed in a fairly complete library of chemistry. To this existing collection there is added annually a constantly increasing volume of material. This chemical literature is the storehouse of the available published information of chemical science and chemical industry. Such a storehouse—the permanent memory of the chemist—can be opened only by those who have become acquainted with its contents. The successful searcher must have acquired the necessary technique—the knowledge of how and where to find desired information in the library.

The object of this book is threefold: first, to sketch briefly the general trend of events giving rise to and accompanying the development of chemical publications; second, to present an outline of the present sources of published chemical information, with a consideration of the general nature of each class and of typical examples in the various classes; and, third, to suggest certain exercises indicating possible laboratory work for class use.

The material included constitutes the basis of an undergraduate course in chemical literature, the general aim of which is to present to the student some conception of the types of chemical information which are available, where they may be found, and how to locate and use them. It has seemed desirable to take up the types of publications, and the method of using them, as lectures and discussions in the class hour. This is done preferably in the library itself. It is obvious, of course, that lectures alone are insufficient to acquaint one with the content and arrangement of the material of chemical publications. The novice in such work must learn by contact with the publications. In order to give experience in this direction, study sheets or library problems have been designed to be used in

connection with certain sections of the book. An attempt has been made to arrange these sheets so that each student may be given an individual assignment without requiring an undue amount of effort and time on the part of the instructor. The sheets are prepared in blank form so that the assignment may be written in the proper place, leaving space for the student to record the information which he has found. Lists of typical assignments have been included.

The nomenclature adopted seems to the author to be that warranted by the usage designated in the standard dictionaries of the English language. This usage is somewhat at variance with that followed by certain writers, who have used the terms, in the course of the development of chemical literature, more or less loosely and, in some cases, with a questionable degree of accuracy.

The author desires to express his indebtedness to various writers from whose works valuable facts and suggestions have been obtained. Among these publications may be mentioned the following: Sparks, "Chemical Literature and Its Use"; Eason, "Where to Seek for Scientific Facts"; Reid, "Introduction to Organic Research"; Mason, "The Literature of Chemistry"; Crane and Patterson, "The Literature of Chemistry"; and various articles which have appeared from time to time in the chemical journals. Valuable suggestions have been received from a number of the assistant editors of *Chemical Abstracts*, and from a number of other individuals. The Mellon Institute of Industrial Research and the Dow Chemical Company very kindly supplied photographs of their chemical libraries.

Any suggestion for the improvement of this book as a text for a course on chemical literature will be welcomed by the author.

M. G. MELLON.

LAFAYETTE, INDIANA,
September, 1928.

CONTENTS

CHEMICAL PUBLICATIONS
THEIR NATURE AND USE

CHAPTER I

INTRODUCTION AND GENERAL OUTLINE

> Very little advance in culture could be made, even by the greatest man of genius, if he were dependent for what knowledge he might acquire upon his own personal observations. Indeed, it might be said that exceptional mental ability involves a power to absorb the ideas of others, and even that the most original people are those who are able to borrow most freely.—*Libby.*

Someone has stated that information of a scientific nature can be obtained, in many cases at least, by one or more of the following procedures: first, by inquiring of the individual who knows; second, by performing the experimental investigations necessary to ascertain the desired facts; and, third, by consulting the scientific literature, where a record may be found of the published reports of others' work upon the subject in question.

Although it may be taking the path of least resistance to resort to the first alternative, provided an individual possessing the information is available, and although it is frequently very desirable to obtain experimental facts first hand, there are many cases in which recourse to either one of these procedures is unnecessary or impracticable. In such instances, the chemist turns to the chemical library. The solubility curve for sodium chloride in water, for example, can probably be given by various individuals, or it may be determined with fair precision by rather simple means; but for ordinary purposes anyone requiring such data would consult solubility tables. It becomes a matter of utilizing recorded chemistry.

Before beginning a journey to some distant point, one usually gives at least passing consideration to the reason for his going

and to the means to be employed in reaching the desired destination. Similarly, before taking up the question of how to use the resources of a library, it seems desirable to give some attention to the kind of inquiries which one takes to such a place, and to the nature of the sources to be examined when one arrives. Since our concern is with chemistry and, therefore, chemical or technical libraries, we should have in mind the kind of questions which a chemist takes to the library. Having familiarized himself with the different sources of information relating to the several types of questions, the searcher is then in a position to make effective use of the material.

At this point, therefore, there is presented a classification of the types of questions for which the material in our various chemical publications may be expected to provide help in finding an answer. The outline proposed[1] is based upon a study of the questions and problems presented to the technological division of the public library in one of our largest cities, where, for eight or ten years, a record was kept of the more important inquiries submitted.

The individuals presenting these inquiries ranged in their chemical interests all the way from commercial research and consulting chemists to boys seeking directions for some chemical trick, or to women requiring popular presentations of subjects for meetings of their clubs. Considering their source, it is not surprising that the questions varied widely in character, just as the questioners varied in their chemical interests. One individual wanted something very specific, such as the spectral transmission curve for a 10 per cent aqueous solution of cupric nitrate; while another wanted to know "all about cement." Some wanted only a popular article or book, while others were satisfied with nothing less than the latest technical data.

An extended examination of the hundreds of questions included in this record—whether specific or general, popular or technical, limited or comprehensive in their nature—indicates that most of them may readily be grouped in rather well-defined divisions. The scheme which has been formulated for this purpose is given below. In it no particular significance is attached to the order in which the various divisions have been placed. There is included

[1] MELLON, *Special Libraries*, **17**, 275 (1926).

for each division a statement of the general nature of the inquiries belonging to it, together with several examples of typical questions.

TYPES OF QUESTIONS

A. Specific.—Those in which the information desired relates to a single phase of chemical activity. The following phases are easily recognized:

1. *Bibliography.*—Partial or complete lists of references, with or without annotations:
   e.g. References on the corrosion of alloys by ammonia.
   The literature on hafnium.
   List of popular articles on gas warfare.
2. *History and Biography.*—Events in the life of an individual or in the development of an industry; the influences operating, and contributions made, during certain periods; the beginning and development of a theory or an industry:
   e.g. Contributions of the alchemists.
   Life of Berzelius.
   Development of the artificial silk industry.
3. *Existence, Occurrence, and Source.*—The location of raw material; its form; compounds which are known:
   e.g. Occurrence of barytes in Canada.
   Commercial source of bromine.
   Fluorine substitution products of meth ne.
4. *Composition.*—Natural materials and artificial products; specifications and standards; formulas and workshop recipes:
   e.g. Formula for automobile lacquer.
   Composition of electrolyte for Edison battery.
   Analysis of Pluto mineral water.
5. *Methods of Production, Preparation, and Manipulation.*—Laboratory and commercial processes; details of procedure; materials required; apparatus employed:
   e.g. Manufacture of stainless steel.
   Preparation of mayonnaise.
   Diazotization of organic compounds.
6. *Properties.*—Physical and chemical (including physiological action); general and specific reactions:
   e.g. Effect of carbon dioxide on individuals in closed rooms.
   Specific heat of calcium chloride brine of sp. gr. 1.33.
   Action of charcoal as a purifying agent.
7. *Uses.*—Laboratory and industrial; general and special applications:
   e.g. Uses of sawdust.
   Industrial applications of silica gel.
   Employment of alkyl bromides in synthetic chemistry.
8. *Identification, Testing, and Analysis.*—Methods available; interpretation of results:

e.g. Detection of pasteurized milk.
Testing of road materials.
Analysis of flue gas.

9. *Patents and Trade-marks.*—Date of expiration; details of specifications; objects previously protected:
   e.g. Details of process for making synthetic methanol.
   Specifications for production of ascarite.
   Date of expiration of patent on Edison cell.
10. *Statistical Data.*—Production, consumption, cost, supply, price, market:
   e.g. Production and supply of helium.
   Statistics on lampblack industry.
   Foreign activities in sulfur industry.

B. General.—Those in which the information desired relates to more than one of the above-mentioned classes. In this case we encounter two variations in the questions:

1. Those in which there is clear indication of the particular classes which are involved:
   e.g. Preparation, properties, and uses of artificial stone.
   Occurrence and composition of natural zeolites.
2. Those in which no such limitations are expressed or implied:
   e.g. Efflorescence on stone and brick.
   Hydraulic cements.

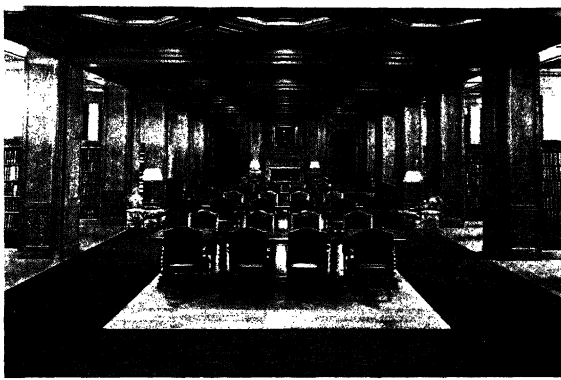
Having in mind the kind of questions a chemist takes to the library, we are next interested in the sources available likely to contain information of value for answering these questions. In considering this part of our problem, attention may be directed briefly, first of all, to the origin and development of those publications which have come commonly to be designated as the chemical literature, noting certain points regarding the state of knowledge and the conditions prevailing at the time the publications were issued. Such an examination furnishes some perspective for judging the comparative value of the records for present-day work.

The Origin and Development of Chemical Literature

We find ourselves today in the midst of a great volume of published material of chemical significance and importance. What was its origin? Why do we have it? Who was responsible for it? How did it reach its present form? These and simi-

lar questions probably do not often disturb the average chemist. They do have some interest, however, in spite of the fact that definite answers are not at once forthcoming.

Numerous works have been published dealing with the historical aspect of various phases of chemistry. Some have been devoted to the activities and contributions of a certain individual; some deal only with the origin, development, and



Library of the Mellon Institute of Industrial Research, Pittsburgh, Pa., containing approximately 17,000 volumes. The literature is most nearly complete from 1900 to date.

significance of an idea or theory; some deal with special industries, with divisions of chemistry, or with countries; and some aim to present a more or less comprehensive view of the whole field. But, curiously, none seems to be available having as its primary aim the presentation of an account of the development of chemical publications as such.[1] In most works of a historical nature, at least occasional references are found to a considerable number of publications. Usually, however, the aim is to direct attention to some individual's idea or contribution rather than to the publication itself.

[1] OSTWALD, "Handbuch der allgemeinen Chemie," Vol. I, "Die chemische Literatur und die Organisation der Wissenschaft."

Even a superficial examination of the material that is available makes certain that it is a long story which recounts the course of man's development to the point of appreciating the significance of the modern scientific method and of applying it to a study of himself and of his environment. Even now, in the words of Millikan:

> Man himself is just . . . emerging from the jungle. It was only a few hundred years ago that he began to try to use the experimental and the objective method, to try to set aside all his prejudices and his preconceptions (as Hugh Black has said, to reject the idolatry of the traditional), to suspend his judgment until he had all the facts before him, to spare no pains to see first all sides of the situation and then to let his reason and his intelligence, instead of his passion and his prejudice, control his decisions. That is called the scientific method.

We now realize that, as a result of the combined contributions of many individuals, there has been acquired a powerful tool in the scientific method, and there has been accumulated an enormous collection of facts, recorded in many places and touching many phases of human activities. The greatest number of significant contributions have been made in the fields of knowledge encompassed by the natural sciences, in which chemistry occupies a commanding position. The written records of these developments include a multitude of facts, experimentally determined, together with discussions and interpretations involving these facts. At present our interest centers on the *publications containing the accounts of the facts and theories*, rather than on the facts themselves, on the methods by which they were discovered or obtained, or on the ultimate effect of the theories developed to account for the facts.

When did man begin to apply to his ideas the test of experimental verification? The answer must remain uncertain. Perhaps it is even not significant. We are convinced, however, that the adoption of the experimental method marked a very important advance in the attainments of the human race; and we are partially aware of the marvelous material changes that have accompanied and grown out of its application in industrial and scientific research work.

What disposal the first enthusiastic workers made of the results obtained by this method we can only guess. It seems entirely

probable that no organized work, as we now undertake it, was done, and that no written records were made, perhaps for centuries. One can imagine some individuals jealously guarding any new information, especially if they were alchemists, and the discovery seemed to offer hope of obtaining the long sought gold; others, perhaps, told their friends in the community. Writing letters to friends, describing the discoveries, must have taken place as a closely related development.

History does not show us by its records the rate of this development, but from them we do know the progress had been sufficient that Francis Bacon, about 1600, formulated a "program for establishing research as a means of regenerating learning in the service of humanity." This included the foundation of a College of Research whose function was to foster the New Philosophy (the experimental and scientific method), and the provision for the publication of such discoveries as were to be given to the world.

Although Bacon did not see his project actively undertaken, his work did produce noteworthy results. The trend of the times became directed more and more toward intelligent experimentation. His "New Atlantis" was intended to be the introduction of an imaginary picture of his college of research in practical operation. This production, according to H. G. Wells, may be considered as one of the ten books which have been most instrumental in shaping and directing human activities. Wells writes that it

> . . . formulated the conception of a House of Science, incessantly inquiring and criticising and publishing, that should continually extend the boundaries of human knowledge; it replaced unorganized by organized scientific research, and did so much to insure the unending continuity of scientific inquiries; and it contains the essential ideas of the modern scientific process—the organized collection, publication and criticism of fact . . . Of the supreme importance of the book itself as the seed of the Royal Society and most European academies, there can be little dispute. Like the rod of Moses, it strikes the rock of human capacity, and thereafter the waters of knowledge flow freely and steadily.

The need of social contact among those devoted to such inquiries began to manifest itself. About 15 years after Bacon's death a group of

> . . . divers worthy persons inquisitive into Natural Philosophy and other parts of humane learning, and particularly what has been called

the "New Philosophy" . . . began by agreement to meet weekly in London to treat and discourse of such affairs.[1]

Out of the efforts of this group, meeting for the purpose of discussing and sharing their intellectual interests, there was founded the Royal Society, already mentioned. Commenting on the significance of this event, Strachey states that

> If one were asked to choose a date for the beginning of the modern world, probably July 15, 1662, would be the best to fix upon. For on that day the Royal Society was founded, and the place of science in civilization became a definite and recognized thing. The sun had risen above the horizon; and yet, before that, there had been streaks of light in the sky. The great age of Newton was preceded by a curious twilight period—a period of gestation and preparation, confused, and only dimly conscious of the end toward which it was moving.

This organization—the Royal Society—stands first in at least two respects; it was the first society of its kind to survive, and it was the first also to publish the proceedings of its meetings.[2] This publication was first printed in 1664 as the *Philosophical Transactions* of the Royal Society, and it has had a continuous existence since that date. Even today one will find the first volume of these records interesting.

Of particular significance to chemists is the fact that Robert Boyle was one of the most active pioneer members. He

> . . . refers to himself as a member of the Invisible College, composed originally of scientific men bound together as an esoteric sodality without name or meeting place and having for its sole end the alleviation of the physical and spiritual ills of humanity.[3]

The time when Boyle and his associates brought about the formation of the Royal Society may be taken as the date of the dawn of chemical literature as we now know it. A simple

L, *Science*, **60**, 25 (1924).

[2] "The Accademia del Cimento, founded at Florence, in 1657, . . . was the first scientific society of any importance . . . Although it lived but ten years, it enriched the world by leaving a volume of important records of experiments, chiefly in pneumatics."—*Mellor*.

[3] LIDDELL, *loc. cit.*

beginning it was, this first systematic recording of scientific papers and discussions, and the preservation of these contributions for posterity; but now the practice is so universal, contributions are so numerous, that one is amazed at more than 3000 periodicals publishing information more or less closely related to the work of the individual engaged in chemical and related pursuits.

> Since 1665, when this first scientific journal put in its appearance there has been an accelerated increase in the number of journals of interest to the chemist, and the bulk of the accumulated material has become almost staggering in its proportions . . . The vastness of the chemical journal literature, its rapid and continuous advance upon the frontiers of our knowledge, and its essentially unorganized state, are . . . arguments why the chemist should see to it that he learns how best to make use of the means which have been provided to make this sea of information navigable.[1]

In 1650, then, we had no scientific journals. At present (1939) more than 3000 are regularly abstracted by *Chemical Abstracts*. Let us examine some of the intervening developments in chemical publications.

It has already been noted that several methods of communicating ideas were probably used during the centuries preceding the appearance of the *Philosophical Transactions* of the Royal Society. Following the inception of this initial serial publication, however, the practice of making a permanent record of individual's contributions started to spread.[2] Gradually, various European academies came into existence, each founding, sooner or later, its own publication.[3] The general condition of affairs during this period necessarily made progress slow. There was still much confusion in the ideas regarding chemical matters. Over a century had to elapse between the founding of the Royal Society and the work of Lavoisier. Following his discoveries,

[1] CRANE, *Ind. Eng. Chem.*, **14**, 901 (1922).

[2] BARNES, *Sci. Monthly*, **38**, 257 (1934); KILMER, *J. Am. Pharm. Assoc.*, **19**, 587 (1930).

[3] See ORNSTEIN, "The Rôle of Scientific Societies in the Seventeenth Century," for developments in England, France, Germany, and Italy; MOORE, "The Rôle of the Scientific Society in Chemistry," *Chemist*, **16**, 327 (1939).

there appeared, in 1778, the first chemical journal, Crell's *Chemisches Journal.* Others followed some years later.

By 1820, the volume of the material appearing had reached a stage where it seemed desirable to collect and summarize the contributions, showing the developments for each year. Accordingly, in 1821, Berzelius began his famous *Jahresberichte über die Fortschritte der physischen Wissenschaften.* This publication represents our first chemical review serial. (The *Berlinisches Jahrbuch für die Pharmacie und für die damit verbunden Wissenschaften* was started in 1795 and continued until 1840.) Not long afterward, a journal seemed justified whose purpose would be the publication of short summaries of each article as soon as possible after the article appeared. *Pharmaceutisches Centralblatt* was begun in 1830 to meet this need. (The *Journal de pharmacie et de chimie*, and *Annales de chimie* had been doing some of this kind of work.) Developments of the present century give ample proof of the vision which these early chemists had regarding the place for such publications.

With a place to publish articles of their own, and a source for summaries of others' work, together with reports of yearly developments, the chemist's needs in this direction seemed to be supplied for the time being. But with the appearance of more and more journals and the constant accumulation of facts in the rapidly widening range of chemical activities, there arose the need for other types of publications. Not more or different journals were needed this time, but rather publications in which could be gathered together, and arranged according to definite schemes, the material already published. Reference works were the answer—digests and treatises, including indexes of known compounds, compilations of chemical properties, discussions of definite fields of the science, dictionaries, and other works.[1]

Early Books on Chemistry

One might well conclude from the preceding statements that there are available no records of chemical matters prior to the founding of the Royal Society. Such is not the case. Although this event did result in the establishment of the first scientific

[1] Spratt, "Scientific Libraries" (1932); "Libraries for Scientific Research in Europe and America" (1936).

journal to survive, various textbooks or treatises on chemistry, pharmacy, and metallurgy were already well known.

On considering that modern chemical ideas began with Lavoisier's work, it seems that the state of chemical knowledge must have been, prior to 1600, such as to make these books of doubtful value to anyone except the chemical historian.[1] Many facts mentioned stand out as accurate observations of the early worker; but the records of his processes are meager, and the recipes of the alchemist are often mysterious, inaccurate, and misleading, in the light of our present knowledge. Bergmann, in his essay "De primordiis chemiae" (1779), wrote: "The history of chemistry is properly divided into the mythological, the obscure, and the certain."

For the purpose of reference there is included a list of some of these early publications.[2] The arrangement is based upon the divisions of chemical activity as used by Brown in his "History of Chemistry." The student should bear in mind that these works were textbooks or short treatises on chemical knowledge and practice of their day, and not reports of experimental work and discoveries resulting therefrom.

1. Prehistoric Period (Up to 1500 B.C.).—As an art, chemistry dates far back of the Christian era. There are no records of chemical practice in this period, but we do find much definite information regarding certain chemical facts mentioned by various writers, as in the Bible. Among these writers may be mentioned the Chaldean, Egyptian, Byzantine, Persian, Indian (Hindu), Roman, and Greek.

2. Alchemical Period (1500 B.C. to A.D. 1650).—The activity of this period was directed toward the search for gold and the philosopher's stone, including the transmutation of the elements. Many practical facts were noted as a result of calcinations, sublimations, and distillations.

[1] See, however, *J. Chem. Education*, **3**, 1149 (1926); **4**, 979 (1927) for English translations of two remarkable Greek papyri, which the translator describes as being by far the most ancient documents we possess dealing with chemical arts and operations as such. They appear to have been written about the end of the third century A.D.

[2] See also MELLOR, "Inorganic and Theoretical Chemistry," v. 1, pp. 19–73 (1922).

History indicates that the Egyptians acquired much knowledge from the Chaldeans. The Arabians appropriated what was known to the Egyptians and the Greeks. There are preserved several Latin translations of writings by Arabians and others of this period, such as "Artis aurifera quam chemiam vocant" (2 v., 1572), "Artis chemiae principes" (1572), "Theatrum chemicum" (1559–1561), and "Bibliotheca chemica curiosa" (Manget, 1702). These profess to be the teachings of Hermes, Ostanes, Plato, Aristotle, Morienus, Geber, Rhazes, Bubucar, Alpharabi, and Avicenna.

Among the Greek writers (speculative philosophers) should be mentioned Heraclitus (540–475 B.C.), who declared, like Bergson, that "becoming" or eternal change is the sole actuality; Aristotle (384–322 B.C.), who formulated the laws of deductive reasoning, that is, from the general to the specific; and Pliny (A.D. 23–79), who wrote the "Historia naturalis," of 160 books, the last five volumes of which are an account of the chemical knowledge of the time.

Other alchemistic writers of the time include Zosismos, Albertus Magnus, Vincent de Beauvais, Thomas Aquinas, Arnoldus Villonovanus, Raymond Lully, and Roger Bacon (A.D. 1214–1284), who advocated the inductive system of philosophy (that is, reasoning from the specific to the general), and who noted the importance and significance of experiment as a tool of research.

3. Iatrochemical Period (A.D. 1500 to 1700).—The preceding period includes the confused times of the Middle Ages, while in the following period we encounter chemistry during the Renaissance, where the search for new medicinal substances became the general aim. The following list includes some of the writers of this period and certain writings ascribed to them:

Paracelsus (1493–1541), "Opera omnia medico, chemico, chirurgica"; 234 publications in all are claimed for him.

Francis Anthony (1550–1623), "Medicinae chymicae et veri potabilis auri" (1610).

Andreas Libavius (1540–1616), "Alchymia" (1585); also other works.

Angelo Sala (1575–1640), "Opera medico-chemica" (1647).

J. B. Van Helmont (1577–1644), "Ortus medicinae vel opera et opuscula omnia" (1648).

Daniel Sennert (1575–1625), "Epitome naturalis scientiae" (1664).

Oswald Croll (1580–1609), "Basilica chemica" (1608).
John Glauber (1604–1668), "Operis mineralis"; others attributed to him.
Werner Rolfinck (1599–1673), "Chymia in artis formam redacta" (1661).
Christopher Baldwin (1600–1682), "Aurum superius" (1675).
Adrian von Mynsicht (1603–1638), "Medico-chemical Treasury" (1662).
Christopher Glaser (1615–1673), "Traité de la chymie" (1663).
Johann Kunckel (1630–1715), "Laboratorium chymicum;" several others.
Nicolas Lemery (1645–1715), "Cours de chymie" (1675); "Pharmacopeé universelle."
Georgius Agricola (1494–1555), "Libri duodecim de re metallica" (1556).
Schrietmann (1525–1600), "Probenbuchlein" (1580).
Albaro Barba (1575–1650), "El Arte de los Metallos" (1640).
Gabriel Plattes (1575–1650), "Discovery of Subterranean Treasure" (1639).
John Webster (1610–1682), "Metallographia" (1671).
Thomas Nicols (1600–1660), "A Lapidary" (1652).

4. Phlogiston Period (A.D. 1650 to 1775).—The aim of this period was directed toward the development of a rational theory of chemistry. The following list includes some of the writers and their contributions:

J. J. Becher (1635–1682), "Metallurgia" (1660); many others.
G. E. Stahl (1660–1734), "Fundamenta chymiae" (1723); also others.
Friedrich Hoffmann (1660–1742), "Opera omnia physico-medica" (about 1725).
Hermann Boerhaave (1668–1738), "Elementa chemiae" (1724); "New Method of Chemistry" (1727).
Johann Juncker (1683–1759), A book on phlogistonism (1730).
Casper Neumann (1683–1738), "Systematic Lectures" (English translation 1760).
J. H. Pott (1692–1777), "Wissenschaften chemischen Untersuchungen" (1746).
S. F. Geoffry (1672–1731), "Tables des rapports" (1718).
P. J. Macquer (1718–1784), "Elemens de chymie théorétique" (1749); "Elemens de chymie pratique" (1751); "Dictionnaire de chymie" (1766).
Robert Boyle (1627–1691), "The Sceptical Chemist" (1661).
Robert Hooke (1635–1703), "Micrographia" (1664).

5. Quantitative Period (1775 to 1900).—The aim of the period was to extend and apply chemical knowledge on the basis of the rational theory developed. The time included by this period coincides with what we often call the development of modern chemistry. Since we are often not aware of the books written

during the earlier part of the period, the following list has been compiled:

Joseph Black (1728–1799), "Lectures on the Elements of Chemistry" (1803).

A. L. Lavoisier (1743–1794), "Opuscules physiques et chimiques" (1774); "Traité élémentaire de chimie" (1789); "Mémoires de chimie" (1805).

Guyton de Morveau (1737–1816), "Elemens de chimie" (1771); "Elemens de chimie théorétique et pratique" (with Maret and Durande) (1776).

M. H. Klaproth (1743–1817), "Beitrage zur chemischen Kenntnis der Mineralkörper" (1795); "Chemisches Wörterbuch" (1807).

A. F. C. de Fourcroy (1755–1809), "A System of Chemistry" ( ); "Philosophy of Chemistry" (1804).

C. F. Wenzel (1740–1793), "Introduction to the Higher Chemistry" (1773); "Lectures on the Theory of the Chemical Affinity of Bodies" (1777).

J. B. Richter (1762–1807), "Elements of Stoichiometry" (1792).

John Dalton (1766–1844), "New System of Chemical Philosophy" (1808).

L. J. Thenard (1777–1857), "Traité de chimie élémentaire théorique et pratique" (1813).

Humphry Davy (1778–1829), "Elements of Agricultural Chemistry" (1813); "Elements of Chemical Philosophy" (1812).

J. J. Berzelius (1779–1848), "Animal Chemistry" (1806); "Treatise on Chemistry" (1808); "Lehrbuch der Chemie" (1825).

Leopold Gmelin (1788–1853), "Handbuch der Chemie" (1817).

Heinrich Rose (1795–1864), "Ausführliches Handbuch der analytischen Chemie" (1829).

Michael Faraday (1791–1867), "Chemical Manipulation" (1827); "Experimental Researches in Chemistry and Physics" (1859).

E. E. Mitscherlich (1794–1863), "Lehrbuch der Chemie" (1829).

J. B. A. Dumas (1800–1884), "Traité de chimie appliquée aux arts" (1826).

Following these men came Liebig, Wöhler, Stas, Bunsen, V. Meyer, Mendeléeff, Laurent, Gerhardt, Wurtz, and many others up to our own time.

Outline of Chemical Publications

Having indicated briefly the origin and development of chemical publications, we may now formulate, perhaps more or less arbitrarily, an outline covering the material available at the present time.

In making a systematic study of the literature of chemistry and chemical technology some classification is needed for the numerous and extensive sources comprising the published infor-

mation relating to the science. Although it is probably impossible to formulate a scheme that is generally acceptable, it is evident that the material may be classified, either according to the nature of the subject matter, as is done in *Chemical Abstracts*, or according to the nature of the publication in which the information appears. This second basis of classification seems the logical

Library of the Dow Chemical Company, Midland, Mich. It contains about 15,000 volumes and 300 current periodicals.

one to adopt for the use of those who want practical assistance in using a chemical library, since periodicals and books are the units of the library and are the containers of the desired information.

The following arrangement, then, is one of publications rather than one of information. The two bases of classification, however, are combined, in a way, since there is included a statement of the kind of information which each type of publication contains. Although an attempt has been made to define the different classes of publications so as to make them properly inclusive and exclusive, it should be understood that, in general, the different sections are not considered as differentiated from each other by a sharp line of demarcation. There is, on the contrary,

more or less overlapping with gradual merging from one to the other.

Publications can be divided into those containing original contributions and those involving compilations of facts already recorded. The original contributions can be further distinguished as being composed essentially of unorganized material, while the compilations are more or less organized, and are arranged according to some definite plan. The papers published by the various chemical societies throughout the world are new material, and the physicochemical constants in the tables of Landolt-Börnstein are systematic compilations of facts previously known but so widely scattered as to be of little use unless collected. The material included under the two main divisions has appeared in a variety of publications, and the subdivisions indicated have been made on the basis of the types of material appearing in these publications. Further subdivisions may be found in the original outline[1] or in the following chapters based upon it.

If one wishes to consider details, the original outline may be expanded as desired by making further subdivisions on the basis of the various branches of chemistry. The thirty divisions used in *Chemical Abstracts* form the best scheme for detailed work. Such consideration would apply particularly to the sections on general works of reference and textbooks, and possibly to the sections under journals; but the advantage is not so apparent in the case of bibliographies, patents, dissertations, and similar publications.

GENERAL OUTLINE

A. Original Sources (Unorganized Information):
Publications containing new material or new presentations and discussions of known material. They constitute the latest published information.

I. Periodicals:
Material that varies widely in character but generally includes original papers, together with one or more of the following items: addresses, review articles, editorials, proceedings of meetings, news items, notes of new books and government publications, market reports, trade announcements and advertisements.

1. Journals of General Science.
2. Journals of Nonchemical Sciences.
3. Journals of Chemistry.

[1] MELLON, *Chem. Met. Eng.*, **33**, 97 (1926).

II. Contributions of Institutions:
Material usually issued irregularly as separate bulletins or pamphlets. Generally new but occasionally composed of compilations and summaries.
1. Public Documents.
2. Reports of Nongovernmental Institutions.

III. Literature on Patents:
Information regarding new patents issued or concerning those subjected to action in the courts or in the patent offices.
1. Letters-patent Documents.
2. Periodicals.
3. Court Records.

IV. Miscellaneous Contributions:
New material not included in previous sections.
1. Dissertations.
2. Manufacturer's Technical Bulletins.

B. Secondary Sources (Organized Information):
Publications containing information compiled from one or more of the preceding classes and arranged according to some definite plan.

I. Periodicals and Serials:
Compilations or digests of material from the original sources; generally regular in time of appearance.
1. Index Serials.
2. Abstracting Journals.
3. Review Serials.

II. Bibliographies:
Lists of the most important or complete references relating to some given subject, usually arranged chronologically or alphabetically by authors. Published as separate contributions or as a part of some article involving the subject in question.

III. General Works of Reference and Textbooks:
Works covering all or part of a given division of chemistry, the material included having been selected from the various original sources and arranged in some definite manner.
1. Works of Reference:
Works ranging from specialized, limited presentations to the comprehensive and exhaustive treatments involving a whole field.
a. Indexes.
Compilations of names and formulas so arranged that references to a given subject may be found as easily as possible.
b. Treatises and Handbooks:
More or less exhaustive surveys of the information in given fields.

c. Monographs:
More or less exhaustive presentations of our present knowledge of a limited field, often in the form of a series of works under a general editorship, but by individual authors.

2. Textbooks:
Manuals of instruction, usually single volumes on special phases of a subject, arranged to be representative of principles rather than exhaustive in their treatment.

IV. Miscellaneous Compilations:
Material not included in previous sections.

CHAPTER II

ORIGINAL SOURCES—PERIODICALS

By a fiction as remarkable as any to be found in law, what has once been published (no matter what the language) is usually spoken of as known, and it is often forgotten that the rediscovery in the library may be a more difficult and uncertain process than the first discovery in the laboratory.—*Lord Rayleigh.*

The publications which contain new material and matter relating to current technological practice, and which are issued, in general, at regular intervals, are designated as periodicals. Their contents ordinarily constitute the latest published information, although one finds occasionally in a book new theories or facts. It is largely from them that the facts are gathered for the preparation of the various publications to be discussed later as secondary sources. These publications in many cases appear under such titles as "bulletin," "journal," "proceedings," and "transactions" (or the equivalent of these terms in other languages), particularly if they are the publications of scientific societies.

The amount of this journal literature of chemistry has become enormous. Liebig's *Annalen der Chemie* alone has now reached over 540 volumes. Starting with one journal in 1664, the *Philosophical Transactions* of the Royal Society, the beginning and development of others has followed so rapidly that more than 3000 are now regularly searched by abstractors for articles of chemical interest. Many of the titles on our present list are additions of the twentieth century. It is well to recall, also, that a complete chemical library would contain more than those now mentioned on the list as being published, since a considerable number survived for a time and then were discontinued. Bolton[1] listed over 400 periodicals of chemical interest, while more recently Crane and Patterson[2] have listed 1889 periodicals of which 1263 were appearing in 1927.

[1] "Select Bibliography of Chemistry," see Chap. VII.

[2] "The Literature of Chemistry," Appendix 6 (1927).

Producers of Periodicals.—Practically all these numerous periodicals are produced as the publication either of a scientific society, a private individual or company, or a commercial publishing concern.[1] The first of these producers includes a large number, while individuals' publications are rare. The general object of the first two has been to furnish a place for authors to publish their papers, and to disseminate other information of interest to the subscribers or members of the societies. The ultimate aim of the commercial publications is profits. With these objects in mind, it is not surprising to find that the general trend of the latter publications is to cater to the industrial interests, and that much of the material in the publications of societies is of a distinctly less practical nature.

A number of periodicals were started in the nineteenth century by individuals whose names became so closely associated with the publication that one finds, especially in the older literature, many references including these names, such as Liebig's *Annalen*, Fresenius's *Zeitschrift für analytische Chemie*, and Hoppe-Seyler's *Zeitschrift für physiologische Chemie*. The man's name is usually that of the first editor. In the *Annalen der Physik*, however, the name changed with each new editor, which accounts for the large number of references such as *Pogg. Ann.*, *Wied. Ann.*, and *Drude Ann.*, referring respectively to Poggendorff, Wiedemann and Drude.

The number of scientific societies of one variety or another which have been formed is surprisingly large. Even those which may properly be designated as chemical make up a considerable group. Bolton's list[2] includes 56 such organizations. Reid[3] has included a later list of chemical societies and their publications. Still more comprehensive are the list of Crane and Patterson[4] and that of Hull.[5]

It is of particular interest to know that chemical societies were organized and in operation in the United States long before they

[1] The *J. Agr. Research* and the *J. Research Nat. Bur. Standards* are published by the United States Government.

[2] *Smithsonian Pub.* 1314, "Chemical Societies of the Nineteenth Century."

[3] "Introduction to Organic Research," p. 73 (1924).

[4] "The Literature of Chemistry," Appendix 5 (1927).

[5] "Handbook of Scientific and Technical Societies and Institutions of the United States and Canada."

existed in Europe. The two pioneers in this field were the Chemical Society of Philadelphia, founded in 1792, and the Columbian Chemical Society of Philadelphia, founded in 1811.

Frequency of Appearance.—Chemical periodicals are published at widely varying intervals of time, the present list including individual examples ranging from publications appearing annually to those issued every week. Proceedings of annual meetings of societies are examples of the former, while the latter include certain trade journals and chemical newspapers. In general, the separate issues of the publications of the national societies appear each month.

Promptness of publication is desired by editor, author, and reader. Usually 2 to 6 months elapse in this country from the time a manuscript is received until it appears in published form. Many journals note the date of receiving a communication. Publication at a considerably later date indicates revision of the original material or failure to issue it promptly. In some periodicals provision is made for more prompt issuance of short "Notes" or "Letters to the Editor."

Distribution by Language and Country.—It would be interesting to have reliable information on the relative number of periodicals produced in different countries in the various fields of chemistry, including the distribution of the material by languages, since some periodicals include various languages. The few limited reports that bear on the subject, such as those by Gross and Gross[1] and by Sheppard,[2] dealt with the citations found in single periodicals. In the 1936 "List of Periodicals" abstracted by *Chemical Abstracts* the percentage of periodicals contributed by the first 10 countries was as follows: United States, 22.2; Great Britain, 18.1; Germany, 14.9; Russia, 7.3; France, 6.2; Japan, 5.5; Italy, 4.8; China, 1.9; Sweden, 1.7; and Belgium, 1.6. It seems safe to state, therefore, that the leading countries scientifically are the United States, Great Britain, Germany, Russia, and France, and that English, German, Russian, and French are the most important languages scientifically.

The Content of Periodicals.—An inspection of the material composing the various periodicals shows a great variation, not

[1] *Science*, **66**, 385 (1927).

[2] *J. Chem. Education*, **12**, 472 (1935).

only in the kind of information to be found, but also in the quality and quantity of certain types. G. B. Shaw's comment, that some literary contributions are extensive and some intensive, applies also to productions dealing with chemistry. It might be added in this case that some are both intensive and extensive, while many could not be correctly designated as possessing either characteristic. The range covered is a wide one, varying from epoch-making papers to mere bits of trade and personal information.

Increasing chemical activity, accompanied by a rise in costs of publication, has made it necessary for editors to stress brevity of presentation until many papers are now little more than extensive abstracts. Some periodicals have arranged to deposit the original manuscript with the American Documentation Institute, 2101 Constitution Avenue, Washington, D. C., from whose Bibliofilm Service one may obtain photographic reproductions of the material.

The character of this material is so diverse, and the manner of publication results in such an intermingling of one type of information with another, that no very satisfactory scheme of classification for these various types is evident. The following is proposed as a possibility which may aid in keeping in mind the general nature of the content of periodicals:

1. Reports of Researches and Discussions Thereof.—These would include most of the publications of scientific societies, covering both pure and applied chemistry. Some of the periodicals are limited to articles in a special field. Book reviews and notices of the activities of societies are often included. As examples of the nonindustrial type there may be mentioned the *Journal of Physical Chemistry,* the *Journal of the Chemical Society,* and *Die Annalen der Chemie;* while on the industrial side the *Transactions of the Electrochemical Society* and the *Transactions of the American Institute of Chemical Engineers* are typical.

Because of the extent of the literature, and the consequent difficulty individuals have in starting work in a new field, it is increasingly important to publish review articles which serve to orient the worker by giving him a bird's-eye picture of the present status of the field. Fortunately, such articles are becoming more common in a number of periodicals, and *Chemical Reviews* is

devoted entirely to such material (also *Reviews of Modern Physics*).

2. Chemical News.—Some periodicals are devoted largely to a consideration of developments in either the general field or some special portion of it. The material consists, for the most part, of advertisements, market reports, trade announcements, reviews of progress, special commercial developments, industrial notes, personal notes (including obituaries), and general news items; many of the items serve as dispatches from the front regarding industrial and scientific advances, including some mention of the means employed and the individuals concerned in accomplishing the advances. Trade journals would be included here. *Chemical Industries, Chemiker-Zeitung,* and the News Edition of *Industrial and Engineering Chemistry* illustrate this type.

In recording the developments in the production of industrial chemicals, technical periodicals usually describe the plant or the process. As the descriptions are never released until operation has been carried on successfully for some years, even the technical articles do not keep the reader abreast of developments. It is necessary that the advertisements for the products be followed so that new arrivals may be noted. Since most new products are developed to be sold, one may expect to find them advertised.

3. Reviews or Abstracts of Articles.—In a number of cases an important part of the periodicals is devoted to abstracts of papers appearing in other periodicals. A discussion of this part of chemical literature is reserved for a later section (see Chap. VI).

4. Combination of Other Types.—Some periodicals publish many articles on research together with a number of the other items already mentioned. One of the best examples of this kind of journal is *Industrial and Engineering Chemistry.* In it may be found editorials, reports of research, articles on commercial developments, addresses, biographical sketches, market reports,[1] and advertisements.

Periodicals Containing Matter of Chemical Interest

The preceding outline indicates the kind of chemical information to be found in periodicals. Not all this information appears

[1] About February the *Oil, Paint and Drug Reporter* issues an extra edition entitled "Annual Market Reviews and Statistical Records."

in our chemical journals, however. In fact, chemical articles are more or less widely scattered through scientific periodicals in general. Depending upon the proportion of their contents which is devoted to chemical matters, the periodicals in which we are interested may be separated into three groups, which will now be considered.

Journals of General Science.—As might be expected, the first scientific periodicals were not limited to any one division of science. Probably no one of these divisions was sufficiently well defined in 1660, or could muster the necessary cooperation and financial support, to warrant undertaking a separate publication. At any rate, we find in the journals of this early period contributions from the several sciences which were then sufficiently evolved to be called such.

These publications are devoted, then, to the various fields of science, including chemistry, since the latter was one of the earliest to develop. Since 1800, the proportion of chemical articles appearing in these journals, compared with the total output of such articles, has become less and less. Although the number now appearing here is relatively small, their quality is often excellent. The names of some of the more important publications of this class are listed below, together with the name of the country in which they are published and their beginning date. The portion of the title in italic bold-faced type shows the standard abbreviation used in citing references to the periodicals.

LIST OF JOURNALS ON GENERAL SCIENCE

Argentina:

1876 ***Anales*** *de la sociedad científica* ***argentina.***

Belgium:

1835 ***Bulletin*** *de la* ***classe*** *des sciences,* ***Académie*** *royale de* ***Belgique.***
1875 ***Annales*** *de la* ***société*** *scientifique de* ***Bruxelles.***

Canada:

1882 ***Proceedings*** *of the* ***Royal Society*** *of* ***Canada.***
1929 ***Canadian*** *Journal of* ***Research.***

France:

1665 ***Journal*** *des* ***scavans.***
1835 ***Comptes*** *rendus hebdomadaires des séances de l'académie des sciences.*
1857 ***Moniteur*** *scientifique du Docteur Quesneville.*

Germany:

1710 *Sitzungsberichte der preussischen Akademie der Wissenschaften.*
1820 *Dinglers polytechnisches Journal.* (Discontinued, 1931.)
1848 *Sitzungsberichte der Akademie der Wissenschaften in Wien.*
1860 *Sitzungsberichte der mathematisch-naturwissenschaftlichen Abteilung der bayerischen Akademie der Wissenschaften zu München.*
1864 *Anzeiger der Akademie der Wissenschaften in Wien.*
1913 *Naturwissenschaften, Die.*

Great Britain:

1664 *Transactions of the Royal Society (London), Philosophical.*
1783 *Transactions of the Royal Society of Edinburgh.*
1798 *Philosophical Magazine and Journal of Science, The London, Edinburgh and Dublin.*
1822 *Transactions of the Cambridge Philosophical Society.*
1832 *Proceedings of the Royal Society of Edinburgh.*
1833 *British Association for the Advancement of Science, Report.*
1840 *Proceedings of the Royal Society (London).*
1866 *Proceedings of the Cambridge Philosophical Society.*
1869 *Nature.*
1925 *Proceedings of the Leeds Philosophical and Literary Society, Scientific Section.*

Holland:

1866 *Archives nêerlandaises des sciences exactes et naturelles* (Now *Physica*).
1898 *Proceedings of the Royal Academy of Sciences of Amsterdam.*

India:

1914 *Journal of the Indian Institute of Science.*

Ireland:

1836 *Proceedings of the Royal Irish Academy.*
1877 *Scientific Proceedings of the Royal Dublin Society.*

Italy:

1847 *Atti della reale accademia nazionale dei Lincei.*
1866 *Atti della reale accademia delle scienze di Torino.*
1907 *Scientia.*

Japan:

1887 *Journal of the Faculty of Science, Imperial University of Tokyo.*
1911 *Science Reports of Tôhoku Imperial University.*
1912 *Proceedings of the Imperial Academy (Tokyo).*
1930 *Journal of Science of the Hiroshima University.*

Mexico:

1887 *Memorias y revista de la academia nacional de ciencias Antonio Alzate.*

Poland:

1889 *Bulletin international de l'académie polonaise des sciences et des lettres.*

Russia:

1828 *Comptes rendus de l'académie des sciences de l'U.R.S.S.*
1836 *Bulletin de l'académie des sciences de l'Union des Républiques Soviétiques Socialistes.*

South Africa:

1903 *South African Journal of Science, The.*

Switzerland:

1795 *Archives des sciences physiques et naturelles.*

United States:

1819 *American Journal of Science.*
1826 *Journal of the Franklin Institute.*
1840 *Proceedings of the American Philosophical Society.*
1848 *Proceedings of the American Academy of Arts and Sciences.*
1883 *Science.*
1915 *Proceedings of the National Academy of Sciences of the United States of America.*
Proceedings of the academies of the various states.

Journals of Nonchemical Science.—The growth and development of the several sciences were accompanied, sooner or later, by the appearance of periodicals devoted to the interests of each of these sciences. As we now well know, none of these fields stands apart by itself, unrelated to any of the others. Biology, for example, cannot detach itself from physics, nor physics from chemistry. It is only to be expected that a journal devoted primarily to some one of these fields, other than chemistry, is bound to contain occasional chemical articles as incidental contributions. Investigations carried on by physicists, with the results published in a physical periodical, are often of great importance to physical chemists.

The number of these borderline publications is so large that no effort has been made to compile a list. The individual making searches of the literature must use his judgment in deciding where articles will be found that might appear in various journals.

Journals of Chemistry.—The remaining group of periodicals is obviously devoted to chemistry and chemical technology. Chemistry, scientific and technologic, has expanded to cover such a range of activities that we have now a basis for a further subdivision. Certain periodicals are devoted to various phases of the science, and may be designated as general journals; the foremost of these include the main publications of the various general chemical societies scattered throughout the world. With the increasing development of specialized lines of chemical work, there have appeared, within the last 50 years, a large number of periodicals devoted to special or limited fields. These may be designated as specialized journals.

The names of some of the more important journals of these two general classes have been collected and arranged in the lists below. In this compilation the aim was to select a representative rather than a complete list.

List of General Chemical Journals

In the case of the general journals the earliest ones available have been included, together with the more important later ones, particularly the publications of all the larger, general chemical societies. The dates included are of interest in showing how one after the other appeared and in indicating the mortality rate of such publications.

1778–1784 *Chemisches Journal für die* **Freunde** *der Naturlehre.*
1781–1794 *Endeckungen in der* **Chemie**, *Die Neuest.*
1783–1798 *Chemisches* **Archiv.**
1784–1802 *Chemische* **Annalen** *für die Freunde der Naturlehre.*
1785–1799 *Beiträge zu den* **chemischen** *Annalen von Lorenz* **Crell.**
1789–1814 *Annales de* **chimie** (changed to):
1815–1914 *Annales de* **chimie** *et de* **physique** (changed to):
1915– *Annales de* **chimie** *and Annales de* **physique.**
1790–1802 *Annali di* **chimica** *e* **storia naturale.**
1795– *Annales des* **mines.**
1798–1802 *Chemical Journal,* **Nicholson's** (changed to):
1803–1813 *Journal,* **Nicholson's** (changed to):
1814–1836 *Chemical Journal, Tilloch's.*
1798–1803 *Allgemeines Journal der* **Chemie**, *Scherer's* (changed to):
1804–1806 *Neues Allgemeines Journal der* **Chemie**, *Gehlen's* (changed to):
1807–1810 *Journal für die* **Chemie**, **Physik** *und* **Mineralogie**, *Gehlen's* (changed to):

1811–1833 *Journal für* **Chemie** *und* **Physik,** *Schweigger's* (changed to):
1834– *Journal für* **praktische Chemie.**
1803–1818 **Archiv der Agriculturchemie** *für denkende* **Landwirthe.**
1809– *Journal de* **pharmacie** *et de* **chimie.**
1823–1831 **Magazin für Pharmacie.**
1825–1876 *Journal de* **chimie medicale,** *de* **pharmacie,** *et de* **toxicologie.**
1825–1885 **Bulletin** *de la société industrielle de* **Mulhouse.**
1828–1833 *Journal für* **technische** *und* **ökonomische Chemie.**
1830– *American Journal of* **Pharmacy.**
1832–1840 **Annalen der Pharmacie** (changed to):
1841–1873 **Annalen der Chemie** *und* **Pharmacie** (changed to):
1874– *Annalen der Chemie.*
1840–1858 **Chemist,** *The*
1841–1843 **Proceedings** *of the* **Chemical Society** *of London* (changed to):
1844–1847 **Memoirs** *of the* **Chemical Society** *of London* (changed to):
1848–1862 **Quarterly** *Journal of the* **Chemical Society** (changed to):
1863– *Journal of the* **Chemical Society.**
1842–1858 **Chemical Gazette,** *The* (changed to):
1859–1932 **Chemical News,** *The.*
1849–1886 **Chemisch-technischen Mittheilungen der neusten Zeit.**
1858–1864 **Kritische Zeitschrift** *für* **Chemie, Physik** *und* **Mathematik** (changed to):
1865–1871 **Zeitschrift** *für* **Chemie** *und* **Pharmacie.**
1859– **Bulletin** *de la* **société chimique** *de France.*
1863–1895 **Chemisch-technisches Repertorium.**
1868– **Berichte** *der deutschen chemischen Gesellschaft.*
1869–1928 *Journal of the* **Russian Physical Chemical Society.**
1870–1877 *American* **Chemist,** *The.*
1871–1892 **Chemical Review,** *The.*
1871– **Gazetta chimica italiana.**
1877– **Chemiker Zeitung.**
1879– *Journal of the American* **Chemical Society.**
1879–1913 *American* **Chemical Journal.**
1880– **Monatshefte** *für Chemie und verwandte Teile anderer Wissenschaften.*
1882– **Recueil** *des* **travaux chimiques** *des Pays-Bas.*
1887– **Bulletin** *de la* **société chimique** *de* **Belgique** *et recueil des travaux chimiques belges.*
1899– **Svensk Kemisk Tidskrift.**
1903– **Anales** *de la sociedad* **española** *de* **física** *y* **química.**
1903– **Arkiv** *för* **Kemi, Mineralogi** *och* **Geologi.**
1903– **Chemisch Weekblad.**
1916– **Canadian Chemistry** *and* **Metallurgy.**
1918– **Helvetica chimica acta.**
1921– **Roczniki Chemji.**
1922– *Scientific* **Papers** *of the* **Institute** *of* **Physical** *and* **Chemical Research** (**Tokyo**).

1923– *Revista de la facultad de ciencias químicas* (*Universidad nacional de La Plata*).
1924– *Journal of the Indian Chemical Society.*
1926– *Bulletin of the Chemical Society of Japan.*
1929– *Collection of Czechoslovak Chemical Communications.*
1931– *Journal of General Chemistry* (*U.S.S.R.*).
1934– *Australian Chemical Institute Journal and Proceedings.*

List of Specialized Journals

In listing current journals which are devoted, wholly or in part, to special fields of chemistry the classification used is based upon the subject or field covered, as followed in *Chemical Abstracts*. The titles included were selected by someone interested in the respective field, and they are intended to be the more generally useful periodicals for this specialty. The date marks the beginning of the publication.

1. Apparatus, Plant Equipment, and Unit Operations:

Beiheft für Varfahrenstechnik (of *Z. Ver. deut. Ing.*), 1936; *Chemische Apparatur*, 1914; *Forschungsheft* (of *Forsch. Gebiete Ingenieurw.*), 1930(?); *Instruments*, 1923; *Journal of the Optical Society of America*, 1911; *Review of Scientific Instruments*, 1930; *Zeitschrift für Instrumentenkunde*, 1881. See Section 13.

2. General and Physical Chemistry:

Acta Physicochimica, U.R.S.S., 1934; *Journal of Chemical Education*, 1924; *Journal of Chemical Physics*, 1933; *Journal de chimie physique et revue générale des colloïdes*, 1903; *Journal of Physical Chemistry*, 1896; *Journal of Physical Chemistry* (*U.S.S.R.*), 1928; *Kolloid-Beihefte*, 1909; *Kolloid-Zeitschrift*, 1906; *Transactions of the Electrochemical Society*, 1902; *Transactions of the Faraday Society*, 1903; *Zeitschrift für anorganische und allgemeine Chemie*, 1892; *Zeitschrift für Elektrochemie und angewandte physikalische Chemie*, 1894; *Zeitschrift für physikalische Chemie*, 1887. Many journals in general science, in general chemistry, and in physics (see Appendix).

3. Subatomic Phenomena and Radiochemistry:

Journal of Chemical Physics, 1933; *Physical Review*, 1893; *Proceedings of the Royal Society*, 1840; *Transactions of the Faraday Society*, 1903; *Zeitschrift für Physik*, 1920; *Zeitschrift für physikalische Chemie*, 1887. Various journals in Section 2.

4. Electrochemistry:

Electrical Engineering, 1887; *Electronics*, 1930; *Engineering Mining Journal*, 1886; *Journal du four électrique et des industries électrochimiques*,

1895; ***Metal Industry, The***, 1903; ***Transactions of the Electrochemical Society***, 1902. Various journals in Section 2.

5. Photography:

British Journal of Photography, 1854; ***Bulletin de la société française de photographie***, 1855; ***Photographic Journal, The***, 1877; ***Photographische Industrie, Die***, 1902; ***Photographische Korrespondenz***, 1864; ***Zeitschrift für wissenschaftliche Photographie, Photophysik und Photochemie***, 1903; ***Photo Technique***, 1939.

6. Inorganic Chemistry:

Zeitschrift für anorganische und allgemeine Chemie, 1892. Many journals in general science, in general chemistry, and some in Section 8 and certain sections on applied chemistry.

7. Analytical Chemistry:

Analyst, The, 1876; ***Annales de chimie analytique et de chimie appliquée et revue de chimie analytique réunies***, 1896; ***Annales des falsifications et des fraudes, Les***, 1908; ***Industrial and Engineering Chemistry, Analytical Edition***, 1929; ***Journal of the Association of Official Agricultural Chemists***, 1915; ***Mikrochemie***, 1923; ***Spectrochimica Acta***, 1939; ***Zeitschrift für analytische Chemie***, 1862. Journals on applied chemistry.

8. Mineralogical and Geological Chemistry:

American Journal of Science, 1819; ***American Mineralogist***, 1916; ***Chemie der Erde***, 1914; ***Comptes rendus (Doklady) de l'académie des sciences de l'U.R.S.S.***, 1936; ***Geologiska Föreningens i Stockholm Förhandlingar***, 1872; ***Norsk Geologisk Tidsskrift***, 1905; ***Schweizerische mineralogische und petrographische Mitteilungen***, 1921.

9. Metallurgy and Metallography:

Journal of the Institute of Metals, 1909; ***Journal of the Iron and Steel Institute***, 1871; ***Metals & Alloys***, 1929; ***Revue de métallurgie***, 1904; ***Stahl und Eisen***, 1881; ***Transactions of the American Institute of Mining and Metallurgical Engineers***, 1871; ***Transactions of the American Society for Metals***, 1920; ***Zeitschrift für Metallkunde***, 1911.

10. Organic Chemistry:

Annalen der Chemie, 1832; ***Journal of Organic Chemistry***, 1936; ***Journal für praktische Chemie***, 1834. Many journals in general chemistry and some in Section 13.

11. Biological Chemistry:

Biochemical Journal, The, 1906; ***Biochemisches Zeitschrift***, 1906; ***Bulletin de la société chimie biologique***, 1914; ***Journal of Biochemistry (Japan)***, 1922; ***Journal of Biological Chemistry***, 1905; ***Journal of General***

Physiology, 1918; *Zeitschrift für physiologische Chemie*, 1877. Many journals more specialized, especially those dealing with microbiology, botany, nutrition, physiology, pathology, pharmacology, and zoology.

12. Foods:

Analyst, The, 1876; *Cereal Chemistry*, 1924; *Journal of the Association of Official Agricultural Chemists*, 1915; *Journal of Dairy Science*, 1917; *Mitteilungen aus dem Gebiete der Lebensmitteluntersuchung und Hygiene*, 1910; *Zeitschrift für Untersuchung der Lebensmittel*, 1898. Many journals devoted to technology of particular foods.

13. Chemical Industry and Miscellaneous Industrial Products:

Angewandte Chemie,[1] 1887; *Canadian Chemistry and Metallurgy*, 1916; *Chemical Industries*, 1914; *Chemical & Metallurgical Engineering*, 1902; *Chemische Fabrik*,[1] *Die*, 1928; *Chemistry & Industry (J. Soc. Chem. Ind.)*, 1882; *Chimica e l'industria, La*, 1935; *Chimie & industrie*, 1917; *Industrial Chemist and Chemical Manufacturer*, 1925; *Industrial and Engineering Chemistry*, 1909; *Industrie chimique belge, L'*, 1914; *Modern Plastics*, 1925; *Revue des produits chimiques, La*, 1898; *Transactions of the American Institute of Chemical Engineers*, 1908.

14. Water, Sewage, and Sanitation:

American Journal of Public Health, 1911; *Engineering News-Record*, 1874; *Journal of the American Water Works Association*, 1914; *Journal of Industrial Hygiene and Toxicology*, 1919; *Sewage Works Journal*, 1928; *Wasser und Abwasser*, 1909; *Water & Water Engineering*, 1899. Journals on industrial chemistry.

15. Soils, Fertilizers, and Agricultural Poisons:

Bodenkunde und Pflanzenernährung, 1922; *Journal of Agricultural Research*, 1913; *Journal of Agricultural Science*, 1905; *Journal of the American Society of Agronomy*, 1907; *Journal of the Association of Official Agricultural Chemists*, 1915; *Soil Science*, 1916.

16. The Fermentation Industries:

Annales de l'institut Pasteur, 1887; *Biochemical Journal*, 1906; *Biochemische Zeitschrift*, 1906; *Enzymologia*, 1936; *Journal of Biological Chemistry*, 1905; *Journal of the Institute of Brewing*, 1895; *Wochenschrift für Brauerei*, 1883; *Zeitschrift für physiologische Chemie*, 1877.

17. Pharmaceuticals, Cosmetics, and Perfumes:

American Journal of Pharmacy, 1829; *Archiv der Pharmazie und Berichte der deutschen pharmazeutischen Gesellschaft*, 1822; *Journal of the American Pharmaceutical Association*, 1912; *Journal de pharmacie et de chimie*, 1845; *Pharmaceutical Journal, The*, 1841; *Pharmazeutisch Weekblad*, 1864.

[1] Parts *A* and *B* of the *Z. Ver. deut. Chem.*

18. Acids, Alkalies, Salts, and Other Heavy Chemicals:

See journals listed in Section 13.

19. Glass, Clay Products, Refractories, and Enameled Metals:

British Clayworker, The, 1892; *Bulletin of the American Ceramic Society,* 1922; *Glass Industry, The,* 1920; *Journal of the American Ceramic Society,* 1918; *Journal of the Society of Glass Technology,* 1917; *Sprechsaal für Keramik-Glas-Email,* 1867.

20. Cement and Other Building Materials:

Cement and Cement Manufacture, 1928; *Ciment, Le,* 1896; *Concrete, Cement Mill Edition of,* 1904; *Journal of the American Concrete Institute,* 1913; *Pit and Quarry,* 1916; *Rock Products and Cement and Engineering News,* 1902; *Zement,* 1911.

21. Fuels, Gas, Tar, and Coke:

Brennstoff-Chemie, 1920; *Fuel in Science and Practice,* 1922; *Gas- und Wasserfach, Das,* 1858; *Industrial and Engineering Chemistry,* 1909; *Journal of the Institute of Fuel,* 1926; *Oel und Kohle vereinigt mit Erdoel und Teer,* 1925.

22. Petroleum, Lubricants, Asphalt, and Wood Products:

Industrial and Engineering Chemistry, 1909; *Journal of the Institute of Petroleum,* 1914; *Neftyanoe Khozyaistvo,* 1920; *Oil and Gas Journal, The,* 1902; *Petroleum, Zeitschrift . . . ,* 1905; *Revue pétrolifère, La,* 1922.

23. Cellulose and Paper:

Cellulosechemie, 1920; *Paper Industry and Paper World,* 1919; *Paper Trade Journal,* 1872; *Papier-Fabrikant, Der,* 1902; *Papier, Le,* 1898; *Proceedings of the Technical Section, Paper Makers' Association of Great Britain & Ireland,* 1921; *Pulp and Paper Magazine of Canada,* 1903.

24. Explosives and Explosions:

Army Ordnance, 1920; *Mémorial de l'artillerie française,* 1928; *Mémorial des poudres,* 1882; *Zeitschrift für das gesamte Schiess- und Sprengstoffwesen mit der Sonderabteilung Gasschutz,* 1906.

25. Dyes and Textile Chemistry:

American Dyestuff Reporter, 1916; *Farben-Zeitung,* 1895; *Journal of the Society of Dyers and Colourists, The,* 1884; *Journal of the Textile Institute, The,* 1910; *Melliand Textilberichte,* 1920; *Textile Colorist,* 1879; *Tiba,* 1923.

26. Paints, Varnishes, and Lacquers:

American Paint Journal, 1916; *Drugs, Oils & Paints,* 1885; *Farben-Zeitung,* 1895; *Journal of the Oil and Colour Chemists' Association,* 1918;

Paint, Oil and Chemical Review, 1883; *Paint and Varnish Production Manager*, 1931.

27. Fats, Fatty Oils, Waxes, and Soaps:

Chemistry & Industry, 1882; *Fette und Seifen*, 1893; *Journal of the Society of Chemical Industry, Japan*, 1930; *Masloboĭno Zhirovoe Delo*, 1925; *Oil & Soap*, 1932.

28. Sugar, Starch, and Gums:

Bulletin de l'association des chimistes, 1882; *Facts About Sugar*, 1914; *International Sugar Journal, The*, 1899; *Zeitschrift der Wirtschaftsgruppe Zucker-industrie*, 1851.

29. Leather and Glue:

Collegium, 1902; *Journal of the American Leather Chemists' Association, The* 1906; *Journal of the International Society of Leather Trades' Chemists*, 1917.

30. Rubber and Allied Substances:

India-Rubber Journal, The, 1884; *India Rubber World*, 1889; *Kautschuk*, 1925; *Revue générale du caoutchouc*, 1924; *Rubber Chemistry and Technology*, 1928; *Transactions of the Institution of the Rubber Industry*, 1925.

Notes on Using Periodicals

Most journals have yearly subject and author indexes, arranged separately or as a combined index. In case several parts of a single year's issue of a journal are bound separately, the index is found in the final part in most cases. If there is no index, usually there will be a table of contents at the beginning of each volume listing the titles of the articles. Many journals have collective or cumulative indexes covering various periods of time, usually 5 years or some multiple of it.[1]

In using periodicals the searcher must always guard against placing too much reliance upon the indexes. Too often they merely index titles or words, and at best they probably never contain entries for all the important points covered by the articles. Chemists, as a class, have not exhibited great aptitude for selecting adequate and effective titles for papers. Thus an article

[1] West and Berolzheimer's "Bibliography of Bibliographies on Chemistry and Chemical Technology" (see Chap. VII) contains, in Part III, a partial list of such collective indexes which have been published. The inclusive volumes and years covered by each index are given.

entitled "Chemical Affinity" really reveals very little concerning its content. Occasionally persistent searchers have been amply rewarded for making page by page searches through whole sets of periodicals.

The standard abbreviation for the name of a journal, as approved by the International Union of Chemistry and used by *Chemical Abstracts*, may be found in the "List of Periodicals" abstracted by *Chemical Abstracts* (see Chap. VI, section on abstracting journals). The entries are alphabetical by abbreviations.

It should be borne in mind that the "List of Periodicals" abstracted by *Chemical Abstracts* included only periodicals being issued at the time of publication of the list. Both Reid[1] and Crane and Patterson[2] have listed the titles of discontinued periodicals. A considerable number of those listed as discontinued represent merely a change of name. Also for checking occasional items on periodicals the following other lists may be useful:

Gregory, "Union List of Serials" (United States and Canada).
Ulrich, "Periodicals Directory."
Wetmore, "Union List" (Chem. Sec.-Special Libraries Assoc.).
———, "World List of Scientific Periodicals."

In printing periodicals the method of handling the references to other publications is an important detail. Generally the citations are (1) placed as footnotes at the bottom of the page to which they refer, and in the order they are mentioned, or (2) gathered together at the end of the article. In the latter case they may be arranged in the order cited, but usually it is preferable to have them arranged alphabetically by authors.

Frequently it is desirable to know the volume number of some journal for a given year, or the reverse of this. Tables containing such synchronistic data for a limited number of periodicals are included in the following books:

Atack-Hope, "Chemists' Yearbook" (Annual).
Beilstein, "Handbuch der organischen Chemie," I, xxvi (1918).
Comey-Hahn, "Dictionary of Chemical Solubilities," p. 1134 (1921).

[1] "Introduction to Organic Research," p. 82 (1924).
[2] "The Literature of Chemistry," Appendix 6 (1927).

Friend, "Textbook of Inorganic Chemistry," each of the later volumes.
Landolt-Börnstein, "Physikalisch-Chemische Tabellen," p. 1634 (1923).
Lange, "Handbook of Chemistry," p. 1538 (1939).
Seidell, "Solubilities of Inorganic and Organic Compounds," **I, 844** (1919).
Soule, "Library Guide for the Chemist," p. 43 (1938).

When occasional errors that escape authors are detected, correction is usually made in a subsequent issue of the periodical. To guard against missing such corrections the searcher should examine the table of contents and the index of the journal for a year or two after publication of the original article.

In many periodicals the professional connection or address of an author is given at either the beginning or end of his article.

CHAPTER III

ORIGINAL SOURCES—INSTITUTIONAL PUBLICATIONS

There are many virtues in books, but the essential value is the adding of knowledge to our stock by the record of new facts. . . . —*Emerson.*

PUBLIC DOCUMENTS

Various federal and state scientific organizations have been established for investigating those matters which concern the common welfare[1] and for securing the desired publicity for the results obtained. It has been stated that the government of the United States is the greatest of all publishers of scientific works.[2] The publications themselves include the results of the investigations of hundreds of governmental workers conducting researches in many divisions of scientific endeavor.

In many instances, large commercial concerns carry on independent research work, often on a large scale; but as such work is usually undertaken for gainful purposes, these concerns feel under no obligation to give the results of their investigations to the world. The governmental bureaus, experiment stations, and laboratories aim to investigate and solve problems for the benefit of a whole industry, frequently under a cooperative arrangement with representatives of the industry. Thus, the operator of limited means, the individual who cannot afford the experimentation necessary to demonstrate the advantages of adopting new procedures for his small-scale operations, has made available for his use the results of various investigations. He has a place to take his difficulties where facilities and trained investigators may be able to offer valuable assistance.

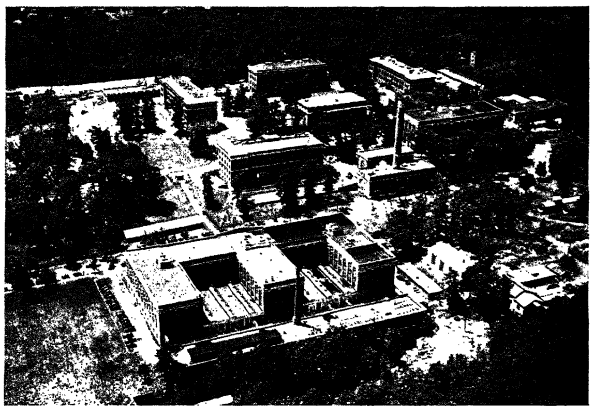
Various countries are conducting this kind of governmental activity to a greater or less extent. It is believed, however,

[1] NORTH, *Ind. Eng. Chem.*, **31**, 574 (1939).

[2] See BIXLER, "Uncle Sam: Author, Printer, Bookseller," *Am. Scholar*, 8, 494 (1939).

that the United States does far more in this direction than any other country; consequently, the present discussion is devoted largely to our own publications. It should not be forgotten, however, that very important contributions come from several foreign institutions.

The publications of these bureaus and laboratories are usually issued irregularly, except the annual reports, in the form of circulars, pamphlets, or bulletins. The material composing the



Airplane view of the buildings of the National Bureau of Standards. (*Photograph by the Air Corps, United States Army.*)

reports includes, for the most part, valuable results of investigations. Occasionally mere compilations of matter published elsewhere, but not readily available, make up the publication, such as bulletins containing the various state mining laws. Frequently the results of investigations carried on in these laboratories are published as articles in some of the journals.

Publications of Federal Institutions

The reports coming from federal institutions will be considered according to the divisions of the government under which the

bureau comes. Although departmental reorganization produces occasional changes, at the present time the following departments maintain, among others, the following bureaus of possible chemical interest:

Department of Agriculture:

Bureau of Agricultural Chemistry and Engineering; Bureau of Animal Industry; Bureau of Dairy Industry; Bureau of Entomology; Bureau of Home Economics; Bureau of Plant Industry; Forest Products Laboratory.

Department of Commerce:

Bureau of the Census; Bureau of Foreign and Domestic Commerce; National Bureau of Standards.

Department of the Interior:

Bureau of Mines; Geological Survey; (Bureau of Fisheries; Biological Survey).

Department of Labor:

Bureau of Labor Statistics.

Navy Department:

Bureau of Supplies and Accounts; Naval Research Laboratory.

Treasury Department:

Bureau of Customs; Bureau of Engraving and Printing; Bureau of Internal Revenue; Bureau of the Mint; Bureau of Narcotics.

War Department:

Various arsenals, such as those at Watertown and Edgewood.

Federal Security Agency:

Bureau of Public Health Service.

Tariff Commission.

Depository Libraries.—A considerable number of libraries have been designated by Congress to receive prints, if desired, of all publications issued by the government for public distribution. A list of these libraries will be found in the "List of Publications of the Department of Commerce." The libraries of all states, territories, land-grant colleges, and many others are included in this list.

Locating Desired Publications.—Without some general sense of direction one's search for federal publications on a given

subject may be tedious, or even fruitless, because of the amount of material available and the problem of finding it.

First of all, there are certain general compilations which serve as guides and indexes to all such publications. They are probably less widely used than the more specific sources mentioned below. Of the comprehensive indexes the following, arranged chronologically, are the most important:[1]

1789–1909 "Check List of U. S. Public Documents" (Supt. of Docs.).
1774–1881 "Descriptive Catalogue of the Government Publications of the United States" (Poore).
1881–1893 "Comprehensive Index to the Publications of the United States Government" (Ames).
1893– "Document Catalogue" (Catalogue of the Public Documents of Congress and of all the Departments of the Government).
1895– *Document Index* (An Index to the Reports and Documents of Congress).
1895– *Monthly Catalogue of United States Public Documents.*
Weekly List of Selected United States Government Publications.

Rather than wait for the appearance of these comprehensive indexes and then rely upon finding information in them, the author prefers to deal with the information available from the individual bureaus. Most of them have their own lists of publications. Next to having these separate lists at hand, it is most helpful to have a knowledge of the kind of work being done in the individual bureaus. One should, for example, refer to the U. S. Geological Survey for information on surface waters of the southwest, to the Bureau of Mines Experiment Station at Pittsburgh, Pa., for coal, and to the Colorimetry Division of the National Bureau of Standards for spectrophotometry.

To provide a general idea of the nature of the work covered by the different bureaus, and to indicate the kind of publications that have been issued thereby, there follows a brief statement

[1] For more detailed information on government documents, see the following books: Boyd, "U. S. Government Publications" (1931); Childs, "Government Document Bibliography in the United States and Elsewhere" (1930); Clarke, "Guide to the Use of United States Government Publications" (1918); Kuhlman, "Public Documents" (1936); Schmeckebier, "Government Publications and Their Use" (1936); Swanton, "Guide to United States Government Publications" (1929); Wilcox, "United States Reference Publications" (1932); Wyer, "United States Government Publications" (1933).

concerning the activities and publications of the bureaus most likely to be the source of important chemical information. More details may be found by consulting either the annual reports of the directors or chiefs of the bureaus, or special pamphlets issued by some of the bureaus. The annual yearbooks of various departments are useful statistical compilations.

U. S. DEPARTMENT OF AGRICULTURE

Bureau of Agricultural Chemistry and Engineering

Organization and Activities.—The activities of the Bureau of Agricultural Chemistry and Engineering may be classified into three fairly well-defined groups, which may be designated as follows: first, research in agricultural chemistry, involving the application of chemistry to agriculture in the most comprehensive sense; second, agricultural chemical technology, or the application of chemistry to the production and utilization of agricultural products; and, third, the enforcement of certain regulatory statutes—that is, the Food and Drugs Act, and the Tea Act. The research activities of the bureau are distributed among the Divisions of Soil Survey, Soil Chemistry and Physics, Chemical Engineering, Proteins and Nutrition, Naval Stores, Industrial Farm Products, Foods, Carbohydrates, and Fertilizers.

In addition to the extensive general laboratories maintained at Washington, D. C., new regional laboratories have been established in Wyndmoor, Pa., New Orleans, La., Peoria, Ill., and Albany, Cal., to specialize on industrial farm products in the four different sections of the country.

Publications.—Publications from the bureau frequently appear as articles in the appropriate journals. There are issued also a large number of technical bulletins, circulars and miscellaneous publications, both from the bureau alone and in conjunction with other bureaus in the department (see Price List 40 and "List of Available Publications" of the U. S. Department of Agriculture).

Forest Products Laboratory

Organization and Activities.—The object of the Forest Products Laboratory, located at Madison, in conjunction with the University of Wisconsin, is to develop new and more efficient methods of converting standing trees into finished products; to increase the possibilities for using both used and unused species; and to find ways of utilizing material which would otherwise be wasted. The work of the laboratory is distributed among several technical sections, of which the following are of most importance to the chemist: Wood Preservation—wood treatment, glue, and laminated construction; Pulp and Paper—manufacturing methods and suitability of various woods for pulp, paper, and special products; Derived Products—chemical properties and uses of wood and chemical wood products, such as turpentine, alcohol, and acetic acid; and Pathology—decay of timber, molds,

stains in manufactured wood products, and antiseptic properties of wood preservatives.

Publications.—Many articles dealing with these subjects appear in the technical journals. In addition, mimeographed reports, bulletins, and circulars are issued (see semiannual "List of Publications" of the Forest Products Laboratory).

Bureau of Plant Industry

Organization and Activities.—The activities of the Bureau of Plant Industry are primarily devoted to agricultural research. The chemical investigations are only incidental to the plant problems and in general are limited to biochemistry and plant physiology. This is particularly true of the investigations involving physiological problems; experiments with drug, oil, and poisonous plants; investigations on the composition and fertility of soils; and problems incident to the study of irrigation.

The work is carried on in the laboratories at Washington, at various field stations, and in cooperation with the state experiment stations.

Publications.—Many of the contributions of this bureau are published as articles in scientific journals. Some are issued as bulletins and circulars of the U. S. Department of Agriculture (see "List of Available Publications" of the U. S. Department of Agriculture).

Bureau of Animal Industry

Organization and Activities.—The activities of the Bureau of Animal Industry are likewise of a general agricultural nature. They are concerned primarily with the production of farm animals and their products; the treatment, control and prevention of diseases of poultry and livestock; and the marketing of animal products in good condition. The work is carried on in laboratories and experiment stations through a number of divisions. Of these, the animal nutrition, the meat inspection, the biochemical, the pathological, and the zoological divisions are doing the most work of chemical significance.

Publications.—The publications of this bureau are issued as separate articles in the appropriate journals, and as bulletins of the U. S. Department of Agriculture (see "List of Available Publications" of the U. S. Department of Agriculture).

Bureau of Dairy Industry

Organization and Activities.—The Bureau of Dairy Industry in its research laboratories is concerned with chemical investigations relating to nutrition and physiology of dairy cows and to the production, manufacture, and utilization of dairy products.

Publications.—The reports issued are similar to those for the two preceding bureaus (see "List of Publications" of the Bureau of Dairy Industry).

Bureau of Home Economics

Organization and Activities.—Among its various activities the Bureau of Home Economics centers its chief chemical research work on foods and nutrition, including the nutritive needs of man, food composition and utilization of food, and on textiles and clothing.

Publications.—In addition to articles in periodicals, the publications include circulars, technical bulletins, farmers' bulletins, and miscellaneous publications (see "List of Available Publications" of the U. S. Department of Agriculture).

U. S. DEPARTMENT OF THE INTERIOR

Bureau of Mines

Organization and Activities.—This bureau was organized to study the safety and health of workers in the mineral industries; to promote greater efficiency and the prevention of waste in the mining, preparation, and utilization of the mineral resources in the United States; and to disseminate information concerning the investigations made. The field of the bureau's activities extends, therefore, from the commercial development of mineral deposits to the production and utilization of the marketable product.

The chemical activities may be grouped under the Technologic Branch, including the Coal, Mining, Metallurgy, Petroleum and Natural-Gas, Nonmetals, and Explosives Divisions; the Economics and Statistics Branch; and the Health and Safety Branch.

The bureau has its headquarters at Washington, D. C., but its investigations are conducted through various experiment stations and field offices. They are located and their work apportioned on the basis of serving special interests in particular sections of the country. The present stations and offices (1939) include Bartlesville, Okla.; Berkeley, Calif.; Boulder City, Nev.; College Park, Md.; Laramie, Wyo.; Minneapolis, Minn.; New Brunswick, N. J.; Pittsburgh, Pa. (central laboratory); Reno, Nev.; Rolla, Mo.; Salt Lake City, Utah; Seattle, Wash.; Tucson, Ariz.; and Tuscaloosa, Ala.

Publications.—The following publications are of chief chemical interest: bulletins and technical papers—results of scientific and technical investigations; reports of investigations—short papers on minor investigations; information circulars—short, informational compilations and reviews; economic papers—statistical studies; periodical service reports (including the monthly *Mineral Trade Notes*)—the market for various minerals. The annual "Minerals Yearbook"[1] summarizes the production and consumption of metals and nonmetallic minerals (see Price List 58; also "List of Publications" of the Bureau of Mines).

[1] Published as "Mineral Resources" by the Geological Survey 1867–1925, and then by the Bureau of Mines to 1932.

U. S. Geological Survey

Organization and Activities.—The Geological Survey carries on a number of important scientific and engineering functions under five field branches, two of which are of special chemical interest. The Geologic Branch investigates the geology and the mineral deposits of the United States and conducts research in geologic and related chemical and physical problems. The Water Resources Branch investigates the quantity, distribution, mineral quality, and utilization of the surface and underground waters. The Conservation Branch examines and classifies the public lands as to mineral and water resources and supervises the technical phases of development operations on public lands under leases, licenses, and permits. The Alaskan Branch investigates and maps the geology, mineral resources, and topography of the Territory.

Chemical laboratories are maintained in Washington by the geologic and water resources branches. These laboratories analyze and identify rocks and minerals, conduct special researches of chemical and physical processes that affect rocks and govern geologic processes, and determine the mineral qualities of surface and underground waters with special reference to their use in irrigation and industry.

Publications.—The most important publications may be grouped as follows: annual reports—review of the year's work; monographs—extensive reports on broad geologic problems or on the geology of special regions; professional papers—shorter reports of a similar nature; bulletins—reports on economic geology and applied geology, including many chemical and mineralogical contributions; water supply papers—reports dealing with the general problem of water supplies and their uses; "Mineral Resources" (prior to 1925, when this work was transferred to the Bureau of Mines)—reports dealing with production, technology and utilization of our mineral resources (see "List of Publications" of the U. S. Geological Survey, particularly the section entitled "Finding List of States, Areas, and Subjects").

U. S. DEPARTMENT OF COMMERCE

National Bureau of Standards

Organization and Activities.—The general function of the National Bureau of Standards is the development, construction, custody and maintenance of reference and working standards used in industry and commerce. This involves, in addition to tests and comparisons made by the bureau, researches relating to the establishment and maintenance of the various standards and units of measurement, the development of measuring instruments and methods of measurement, the determination of physical constants, and the properties of materials. The work necessarily covers a very wide field. The scientific and technical divisions of the bureau are Weights and Measures, Electricity, Heat and Power, Optics, Chemistry, Mechanics and Sound, Organic and Fibrous Materials, Clay and Silicate Products, Metal-

lurgy, Simplified Practice, Trade Standards, and Codes and Specifications. Each of these major divisions is made up of several sections which deal with definite classes of problems.

The work of the chemistry division[1] includes the investigation of the chemical composition and purity of materials, studies of chemical properties and constants, researches in connection with methods of analysis, and the preparation of specifications for technical materials for other departments of the government and for industrial and scientific laboratories.

Publications.—Many valuable contributions have been published in pamphlet form in the following separate series: (*S*) scientific papers,[2] (*T*) technologic papers,[2] (*C*) circulars, (*H*) handbooks, (*R*) simplified practice recommendations, (*CS*) commercial standards, (*BH*) building and housing, (*BMS*) building materials and structures, (*M*) miscellaneous publications, such as "National Directory of Commodity Specifications," and (*LC*) letter circulars, the last in mimeographed form. They cover a wide range of subjects in the field of physical measurements and the properties of materials and are issued for general distribution to the scientific, technical, and industrial interests concerned with the subjects treated. An official distribution of a limited, free edition includes single copies to the technical press, designated government depository libraries, those collaborating with the bureau in its investigations, and certain specialists concerned with the subjects treated (see Price List 64, "List of Publications" of the U. S. Department of Commerce, and the monthly *Technical News Bulletin* of the National Bureau of Standards).

Bureau of Foreign and Domestic Commerce

Organization and Activities.—The Bureau of Foreign and Domestic Commerce is organized in two divisions: the Washington or central staff; and the district offices located in 25 leading trade centers of the United States. The function of this organization is to gather and disseminate information covering commercial conditions at home and abroad.

The bureau answers specific requests from manufacturers, exporters, and others for specific statements on problems of particular interest to the writers. Expert information is furnished by a number of commodity or industrial service divisions, of which the following are probably most closely connected with the interests of chemistry:

Chemical	Machinery
Foodstuffs	Minerals and Metals
Forest products	Specialties
Leather and rubber	Textiles

Publications.—Several types of publications are issued. *Commerce Reports*—the weekly journal of the bureau—contains a great variety of

[1] See Washburn, *Sci. Monthly*, **37**, 20 (1933).

[2] Combined, in 1928, as *J. Research. Nat. Bur. Standards*. Reprints are designated Research Papers (RP).

articles dealing with economic conditions and movements throughout the world. Each commodity division publishes weekly, in its own section of *Commerce Reports*, items of special interest to the trades it serves.

Besides *Commerce Reports*, bulletins and circulars on a wide range of special subjects or countries are published, both regularly and occasionally. Regular statistical publications are: *Foreign Commerce and Navigation*, of the United States (annual); *Monthly Summary of Foreign Commerce*, of the United States (monthly); *Trade of the United States with the World* (biennial); and *Survey of Current Business* (monthly). *Trade Information Bulletins* and the *Trade Promotion Series* present special and timely reports that are too long for *Commerce Reports*.

American merchants and manufacturers interested in oversea trade may have their names placed upon the lists known as the *Exporter's Index* and the *Importer's Index*. They are then supplied with reserved and confidential information on foreign trade opportunities and trade lists and with other helpful data received from abroad. The "Market Data Handbook"[1] presents data on industrial production, employment, value of products, cost of material, fuel, and power for nearly 300 industries in the 3,070 counties of the United States.

Standard specifications adopted by the American Society for Testing Materials are published as an *Industrial Standards Series*. They cover industrial standards for materials which include standards prepared by the government and by technical societies and other organizations (see "List of Publications" of the Bureau of Foreign and Domestic Commerce).

Bureau of the Census

Organization and Activities.—The Bureau of the Census compiles and publishes, in addition to information regarding population, valuable statistics relating to agriculture and industry.

The Division of Manufactures collects statistics biennially on chemical industries for which figures can be shown without disclosing the operations of individual companies. These figures include the number and location of plants, employment, wages and salaries, cost of materials used, total value of products manufactured, value added by manufacture, and the amount of various chemicals produced. The current statistical service in this division prepares monthly statistics on the preparation of methanol, cellulose plastic materials, sulfuric acid and superphosphate, and also monthly figures on manufacturers' sales.

The Division of Cotton and Oils collects quarterly statistics on factory production, consumption and factory and warehouse stocks of many vegetable, animal, and marine animal oils.

The Division of Business collects biennial statistics by industries, including the chemical industries, on distribution of sales by manufacturers.

Publications.—The information is issued in the following forms: monthly and quarterly releases—single or multiple sheets (mimeographed) containing

[1] Published in cooperation with the bureaus of the census and mines.

monthly and quarterly statistics by commodities; preliminary industry reports—single or multiple sheets containing preliminary figures for each industry; industry bulletins—containing selected statistics by industries for a particular census; and final reports—bound volumes containing all statistics prepared for a particular census. These include the "Biennial Census of Manufactures"[1] and the decennial, or main, "Census of the United States." The 15th decennial report (1930) included three volumes on manufactures: I, General Report, statistics by industries; II, Reports by Industries; III, Reports by States and Industrial Areas.

The "Statistical Abstract of the United States"[2] is an annual comprehensive digest of data collected by all statistical agencies of the government.

FEDERAL SECURITY AGENCY

UNITED STATES PUBLIC HEALTH SERVICE

Organization and Activities.—Various fields of activity are represented in the operations of the Public Health Service, including scientific research, notably at the National Institute of Health (formerly the Hygienic Laboratory), where investigations are conducted on infectious and other diseases with reference to their cause, method of spread, and treatment. The Cancer Institute, a part of the National Institute of Health, is devoted exclusively to the study of the cause, the method of treatment, and the prevention of cancer. The chemical investigations of the Service include such subjects as fundamental studies on the carbohydrates, the removal of fluorine from drinking water, the synthesis of drugs, morphine derivatives, sulfanilamide derivatives, fundamental cancer studies, and other chemical and chemopharmaceutical problems.

Publications.—Some of the more important printed publications are the following: annual reports—summaries of the year's activities; National Institute of Health Bulletins—comprehensive technical reports on research; *Public Health Reports* (weekly)—reports of disease prevalence and current brief reports on research; supplements to and reprints from the *Public Health Reports* (numbered serially); *Venereal Disease Information* (monthly)—laboratory research, pathology, diagnosis, treatment, and public health administration in the venereal diseases; and Public Health Bulletins, material relating to public health problems and public health administration (see semiannual "List of Public Health Service Publications").

U. S. TARIFF COMMISSION

Organization and Activities.—The U. S. Tariff Commission is a separate organization of the government. In connection with the establishment of the tariff schedules it collects statistics on the domestic production and sales of a wide variety of commodities, including many chemical products.

[1] Not issued separately in the year of the decennial census.

[2] Published with the cooperation of the Bureau of Foreign and Domestic Commerce.

The annual publication on synthetic organic chemicals is typical and includes for each compound the manufacturers reporting (if at least three), total production and sales (quantity and value). Publications covering imports are issued jointly by the Department of Commerce and the Tariff Commission.

Publications.—The information is published in the form of reports under several designations (see "Subject Index of Tariff Commission Publications").

TREASURY DEPARTMENT BUREAUS

The five agencies in the Treasury Department that maintain chemical laboratories are the Bureau of Customs, where commodities are examined for establishing duties; the Bureau of Engraving and Printing, where the work is primarily with papers and inks; the Bureau of Internal Revenue, Alcohol Tax Unit, which is concerned with the tax classification of all articles on which there is an internal revenue tax; the Bureau of the Mint, where gold and silver are assayed; and the Bureau of Narcotics, where suspected samples are examined and research is conducted.

Since much of the work of these laboratories is routine in nature, ordinarily no special publications are issued. Consequently, our primary concern in them is to know the kind of work carried on in each so that personal communication may be employed when knowledge is desired on items of interest.

MISCELLANEOUS FEDERAL AGENCIES

A number of Federal agencies are not concerned primarily with research or the publication of technical material and statistical data, but they do issue occasional compilations of regulations or other matter in which those dealing in chemicals have some interest.

Industrial chemists are concerned with regulations for the safety of employees and safe carriage of packages. These items are covered by publications such as the following: "Regulations for transportation by rail of explosives and other dangerous articles by freight and express, and in baggage service, including specifications for shipping containers" (Interstate Commerce Commission); "Navigation laws of the United States" (Bureau of Navigation, Department of Commerce); and "Postal laws and regulations" (Post Office Department).

The Bureau of Labor Statistics, Department of Labor, issues monthly pamphlets entitled *Wholesale Prices* and *Retail Prices*.

Typifying large organizations, the United States Government employs specifications for the purchase of commodities. The work of the National Bureau of Standards in promulgating specifications, through its "National Directory of Commodity Specifications" and the "Commercial Standards" series, has already been mentioned. The Federal Specifications Board lists all specifications for government purchases in the "Federal Standard Stock

Catalog." Reprints for the individual items covered are issued as "Federal Specifications." The War Department issues "Materials and Process Specifications, U. S. Army, as Used by the Air Corps," and the Navy Department, Bureau of Supplies and Accounts, issues an "Index to Specifications Used by the Navy Department for Naval Stores and Materials." The "Yearbook of the American Standards Association" is an annual review of standardization activities. It parallels the "Handbook of the British Standards Institution," the German "D.I.N. Normenblatt-Verzeichnis," and the "Catalogue des normes et documents homologués par le Comité Supérieur de Normalisation" of the Association Française de Normalisation.

Obtaining Federal Documents.—Several arrangements may be used to obtain copies of U. S. public documents. Occasionally it is possible to secure them free by writing one's congressman or the person in charge of the division of work concerned. Such distribution generally applies only to the smaller publications, such as circular letters and pamphlets.

The other alternative is to buy the publications. Any of the following procedures is satisfactory:

1. Send check, postal money order, express order, New York draft, or currency (at sender's risk) in advance of shipment of publications, making payable to Superintendent of Documents, Government Printing Office, Washington, D. C. Postage stamps, foreign money, and smooth or defaced coins are not accepted.
2. Enclose coupons with the order. Coupons may be purchased (20 for $1) from the Superintendent of Documents and are accepted as cash for any requested publications.
3. Use the deposit system, by depositing five dollars, or more, with the Superintendent of Documents. The cost of publications, as ordered, is charged against the deposit. This system avoids remittances with every order and delay in first obtaining prices.
4. Order publications sent C.O.D. if they are needed immediately and the price is unknown. Payment is made when they are received.

Free price lists of all government publications are available from the Government Printing Office, or the various departments and bureaus will supply their particular lists. Those of most current chemical interest follow:

No. 11, "Foods and Cooking"; 15, "Geological Survey"; 31, "Education"; 36, "Government Periodicals"; 38, "Animal Industry"; 43, "Forestry"; 46, "Agricultural Chemistry"; 51, "Health"; 56, "Smithsonian Institution

Reports"; 58, "Mines"; 62, "Commerce and Manufactures"; 64, "Standards of Weight and Measure"; 70, "Census Publications"; and, 75, "Federal Specifications."

Publications of State Institutions[1]

In addition to the extensive list of public documents issued by the several federal departments, we have, in the aggregate, a large number of publications coming from similar institutions which are under the control of the state governments. As intimated, these publications are not essentially different in character from those already considered. Frequently the subjects treated have a distinctly local significance; but probably just as often the subject matter is of more general interest than many productions of the federal bureaus.

Two of the main sources of these publications are the state engineering and agricultural experiment stations, which, incidentally, are located in many cases at the state universities. The general function of the former of these stations is to conduct investigations along various lines of engineering and to cooperate with engineering societies in pursuing industrial investigations, particularly for the engineering interests of the states. The agricultural investigations bear a similar relationship to the agricultural interests of the states.

One of the functions of these institutions is to publish the results of their work. This usually takes place in the form of bulletins. One may secure lists of available publications by writing the director of the various stations, and ordinarily copies of the bulletins may be secured in a similar manner, without charge.

Certain other state institutions issue publications which are less numerous but often of value, such as the annual reports of the state boards of health and the bulletins of the state geological surveys.

All publications of state institutions, such as experiment stations, geological surveys, boards of health, and similar organizations, are listed in the *Monthly Check List of State Publications*, Superintendent of Documents, Washington, D. C., $1 per year.

[1] See REECE, "State Documents for Libraries" (1915).

Publications of Foreign Institutions[1]

In various foreign countries scientific work comparable to that in the United States is being carried on under governmental supervision. In general, such activities are not so extensive as our own. The present discussion is limited to the presentation of sources for further information.

Great Britain:[2] "Government Publications" (monthly and annual consolidated lists); "List of Publications of the Department of Scientific and Industrial Research" (covers the National Physical Laboratory and the Chemistry Research Board); "List of Publications of the Medical Research Committee"; "Reports on the Work of Agricultural Research Institutes" (annual); "Reports of the Imperial Institute" (annual); and "Reports of the British Mines Department."

Canada: Reports of the National Research Council and the departments of agriculture, mines and resources, national revenue, and pensions and national health.

India: Reports of the Indian Research Bureau of the government of India.

Germany: "Monatliches Verzeichnis der reichsdeutschen amtlichen Druckschriften."

REPORTS OF NONGOVERNMENTAL INSTITUTIONS

Publications are also issued from several institutions whose financial status is such that they should hardly be included among those already discussed as governmental projects. These institutions are maintained, or were started at least, by private endowments. They may be under the general supervision of some governmental agency. The nature of the publications themselves does not differ from that of public documents. Two typical institutions of this kind will be considered briefly.

Smithsonian Institution.—According to its seal, this institution, situated in Washington, D. C., was established upon a broad basis—"For the increase and diffusion of knowledge among men." An inspection of the list of publications, obtained from

[1] See GREGORY, "List of the Serial Publications of Foreign Governments." For the period 1927–1933 the annual "Standards Yearbook" of the National Bureau of Standards reviewed the work of standardization throughout governmental laboratories.

[2] For general information, write the British Library of Information, 270 Madison Ave., New York City.

the director, indicates a wide range of activities. The regular publications include *Smithsonian Contributions to Knowledge, Smithsonian Miscellaneous Collection,* and the "Smithsonian Annual Report." The first of these includes memoirs, embracing the records of extended original investigations and researches, resulting in what are believed to be positive additions to the sum of human knowledge. The miscellaneous collection was designed to contain reports of the present state of our knowledge of particular branches of science; instructions for collecting and digesting facts and materials for research; lists and synopses of species of the organic and inorganic world; museum catalogues; reports of explorations; and aids to bibliographical investigations (see "List of Publications").

The Carnegie Institution of Washington.—The corporation endowed by Andrew Carnegie and incorporated as the Carnegie Institution of Washington has for its object, "To encourage in the broadest and most liberal manner investigation, research and discovery and the application of knowledge to the improvement of mankind." Accordingly, means are provided to undertake large problems within the institution itself, and to help individual investigators, in other institutions, where elaborate facilities are not required.

The institution aims to lend its work, whenever possible, to advance fundamental research in fields not normally covered by the activities of other agencies, and to concentrate its attention upon specific problems, with the idea of shifting attack from time to time to meet the more pressing needs of research as they develop with the increase of knowledge.

The projects carried on within the institution are scattered among several laboratories. The ones of chief chemical interest are the Laboratory of Plant Physiology at Tucson, Ariz.; the Nutrition Laboratory at Boston, Mass.; and the Geophysical Laboratory at Washington, D. C.

Publications.—Many of the contributions coming from these laboratories are published in scientific journals. Others are issued under the title of *Carnegie Institution Publications* (see "Price List of Publications").

CHAPTER IV

ORIGINAL SOURCES—LITERATURE ON PATENTS

For words, like Nature, half reveal and half conceal the Soul within.—
Tennyson.

The subject of patents is a very specialized one, and the sources of information relating to it are such that a special section has been devoted to its consideration. One might, of course, group the publications coming from the various patent offices along with public documents, in view of the fact that these offices are governmental institutions.

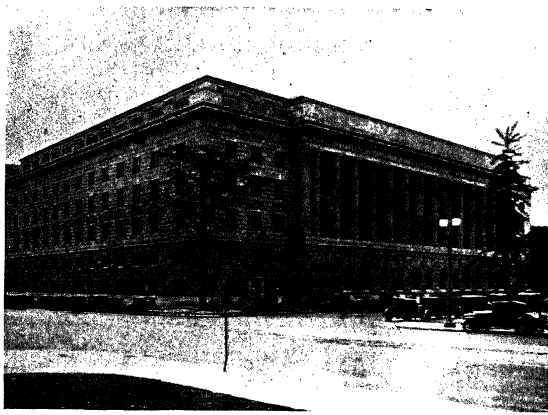
In considering the patent literature, we are concerned with at least three questions: (1) Of what value is it to the chemist? (2) What are the significant publications? (3) What are the methods and facilities for using them?

The Chemist's Interest in Patents

An alert and competent chemist should be a potential inventor. If he possesses an imaginative temperament and an analytical mind, he should be capable of detecting defects in old procedures and of devising preferable alternatives. Assuming that he is endowed with creative or inventive capacity, and that he is trying to develop a new process or product, or to improve a process or product already being used or manufactured, he is very likely to have an interest in those objects which are patentable; that is, a process, a machine, a manufacture,[1] a composition of matter, or a new plant (botanical). In searching patents, he will have, in general, one or more of the following objectives: to learn everything that is recorded relating to a given subject; to determine whether an idea is patentable; to determine the scope and validity of existing patents.

[1] An article for use produced from raw or prepared materials by giving them new forms, qualities, properties or combinations.

In the latter connection it may be noted that information regarding patents that have been issued, or concerning those being subjected to action in the courts or in the patent offices, is often of very great importance, particularly to the industrial chemist.[1] The tens of thousands of chemical patents deal not only with nearly every conceivable phase of industrial activity but also with laboratory developments having merely possibili-



Building housing the United States Patent Office.

ties of commercial exploitation. Although the disclosures are supposedly complete, actually it is not uncommon to find deliberate obscurity in the description.

Barrows[2] has given in the following statement a good summary of the general significance of patents to chemists:

Patents, from their very nature, require consideration from various aspects other than as a part of the chemical literature. Thus, the patentability of inventions, the filing and prosecution of applications for patents, the construction, validity, and scope of issued patents,

[1] BROWN, *Ind. Eng. Chem.*, **31**, 580 (1939).
[2] *Chem. Met. Eng.*, **24**, 517 (1921).

questions of infringement of unexpired patents, patent litigation, property rights in patents, the rights and obligations of patentees, etc., are matters primarily involving patents as patents rather than as publications, and are matters requiring consideration from the standpoint of the relevant principles of the patent law applicable thereto, as well as from the standpoint of the chemical principles that are involved.

Patent searches or investigations may thus be of a special character. In considering questions of infringement, for example, the primary search extends only through the United States patents granted during the last seventeen years and requires consideration of the invention claimed rather than, or in addition to, the invention described, but inasmuch as the claims of a patent may require to be construed by the accompanying description and in the light of the Patent Office proceedings leading up to the grant of the patent, as well as in view of the prior state of the art disclosed by prior patents and publications, and in accordance with relevant principles of the patent law, a more extended search to include expired United States patents and other patents and publications may be important or even essential.

Investigations of the patentability of inventions, such as are made to determine the advisability of making application for a patent, or by the Patent Office examiners in determining the patentability of inventions set forth in patent applications, as well as investigations of the scope and validity of issued patents, may likewise require an extended search of the prior patents and publications, to determine whether the invention is new and whether it is a patentable invention or discovery, within the meaning of the patent law.

Patent investigations thus include both investigations of patents as patents, and investigations or searches of patents as publications and as a part of the chemical literature.

Considered as a part of the chemical literature, the patent literature furnishes one of the most important fields of search, inasmuch as it records the inventions and improvements, and hence the progress, made in almost all fields of chemical industry. Not infrequently inventors have patented their inventions without having published any descriptions of them elsewhere and without any abstracts or digests of their inventions appearing in the periodical literature. The patent literature, therefore, contains much that is not available elsewhere.

Before taking up the publications constituting the patent literature, it will be well to consider the nature of a patent. When we state that an individual has a patent, reference is made to the letters patent issued to the patentee by the government

(U. S.). These documents consist of the grant, the specifications, and the drawings, if there are any, including complete and full disclosure of the invention.

The grant is a paper containing a short title of the invention and purporting to grant to the patentee, his heirs and assigns, for a period of 17 years from the date of issue, the exclusive right to make, vend, or use the invention throughout the United States and the territories thereof. What really is granted is the right to prevent others from making, using, or selling the invention.

The specifications are the information furnished by the patentee regarding the object or process patented. This section of the letters patent consists, in addition to any drawings, of two parts:

> . . . The *description* is a disclosure of the invention, and of the manner or process of making, constructing or compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, or compound, and to use the same . . . The function of the *claims* is to define the exact limits of the invention, and no matter what has been described in the body of the specification, or illustrated in the drawings, the invention patented is the invention set forth in the claims—nothing more. The patentee is bound by his claims, and these will not ordinarily be enlarged by reference to the specifications. Failure to claim described matter dedicates it to the public use, unless claimed in other applications which should be properly referred to.[1]

The Patent Literature

Although over 100 countries grant patent protection[2] and a considerable number issue official publications from their patent offices, the discussion is confined, for the most part, to the practice followed in this country, and to the publications of our own patent office. These publications will be considered under three divisions.

Letters-patent Documents.—These are copies of the original patents, and include the description[3] and claims, in addition to

[1] Geier, "Patents, Law and Practice," p. 11 (1930).

[2] Smith, *Ind. Eng. Chem.*, **16**, 527 (1924).

[3] An idea of the range in size of United States patents is provided by the

the heading, which includes the date of issuing the patent, its number, the name and address of the patentee, the title of the patent, and the date of application for the patent. A typical United States chemical process patent is given here.

following examples:

D. Isenberg, No. 1,650,071, on paint, consisting of one-third page of description, including one claim; W. S. Gubelman, No. 1,817,451, on a calculating machine, consisting of 40 sheets of drawings and 205 pages of description, including 975 claims; and A. E. Ischinger, No. 2,101,048, on a knitting machine, consisting of 170 sheets of drawings and 146 pages of description, including 250 claims.

Patented Dec. 29, 1925. **1,567,159**

UNITED STATES PATENT OFFICE

BRIAN MEAD, OF BOSTON, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL MOTORS CORPORATION, OF DETROIT, MICHIGAN, A CORPORATION OF DELAWARE.

METHOD FOR PRODUCING LEAD COMPOUNDS

Application filed June 14, 1923. Serial No. 645,465

To all whom it may concern:

Be it known that I, BRIAN MEAD, a subject of the King of Great Britain, residing at 61 Mountfort Street, Boston, Massachusetts, have invented certain new and useful Improvements in Methods for Producing Lead Compounds, of which the following is a full, clear, and exact description.

This invention relates to modes of producing lead tetraalkyls, and, more particularly, lead tetraethyl, and its principal objects are to promote an intimate relation between the substances employed and to electrically reduce the reaction mass.

In the accompanying drawings:

Fig. 1 is a plan view of an apparatus adapted to carry out my process; and

Fig. 2 is a sectional view thereof, taken substantially on the line 2—2 of Fig. 1.

In these drawings 10 is a tank containing a porous cup 11 made of clay or other material, which divides the interior of the tank into an inner chamber 12 within the cup and an outer chamber 13 between the cup and the tank walls. A series of graphite anodes 14 (shown herein as six in number) are held in vertical positions in the outer chamber 13 by a tank cover 15 through which the anodes project. The outer ends of the anodes are connected in an electrical circuit by a wire 16.

The porous cup 11 has a cover 17 of non-conducting material, for example, hard rubber, sealed along its periphery by asphalt 18. Metal ferrules 19 with rubber attachment seated in the cover 17 support leads 20 which are attached at their inner ends to an annular lead cathode 21 and at their outer ends to a wire 22 connected in the electrical circuit with wire 16. 23 is a thermometer, and 24 a reflux condenser having a condensing chamber 25 communicating with the inside of cup 11, and a cooling chamber 26 having connections for circulating a cooling medium about the condensing chamber 25. Mounted on the cover 17 is a mercury seal 27 for an agitator comprising a rod 28 projecting through the seal, gears 29 connecting the outer end of the rod with a power shaft 30 and propeller blades 31 on the inner end of the rod.

The cell is placed on a hot plate 32 or similar means for controlling the temperature of the electrolyte.

The chamber 12 within the cup

Dec. 29, 1925. 1,567,159

B. MEAD

METHOD FOR PRODUCING LEAD COMPOUNDS

Filed June 14, 1923

Fig. 1

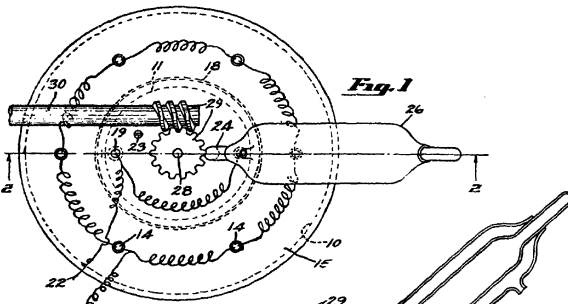
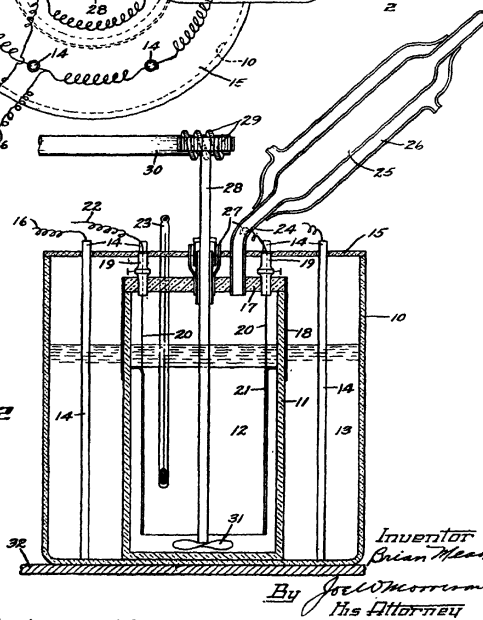


Fig. 2



Inventor
Brian Mead
By Joel W. Morrison
His Attorney

Drawing forming a part of the specifications of U. S. Patent No. 1,567,159.

is partially filled with a catholyte comprising by weight 90 parts of water, 10 parts of NaOH, 10 parts of ethyl iodide, and 1 part casein, and the chamber 13 around the cup is partially filled with an anolyte comprising 10 parts NaOH in 90 parts of water. The electrolyte is heated to about 55°C., or just below the boiling point of the ethyl iodide, the agitator is started, and the current is turned on, a current density of about 1.15 ampere per dm^2 being preferred. The reflux apparatus condenses and returns to the cup the ethyl iodide which vaporizes during the reaction. The stirring produces an emulsion of casein and ethyl iodide in the water and this emulsion promotes homogeneity of the mixture and an intimate contact between the ingredients of the cell and, more particularly, between the ethyl iodide and the lead. Apparently the hydrogen formed at the cathode reduces the reaction mass, forming lead diethyl which is unstable at the temperature used and breaks up thermally into lead and lead tetraethyl. The lead tends to settle to the bottom of the cup.

When the reaction is completed, the NaOH is decanted off and the heavier lead tetraethyl is steam distilled out and collected in another vessel.

The composition of the reaction mass may be varied by using in place of the ethyl iodide, other alkyl halides, for example, methyl iodide, amyl iodide, and methyl, amyl, and ethyl bromides.

Slight alkalinity of the electrolyte promotes the reaction and avoids acidity which is detrimental to the reaction.

I claim:

1. The process of producing a lead alkyl which comprises forming an emulsion of an alkyl halide in water, placing lead in contact with the emulsion, and reducing the reaction mass thus formed.

2. A process as set forth in claim 1 in which the temperature of the reaction mass is maintained slightly below the boiling point of the alkyl halide.

3. A process as set forth in claim 1 in which the alkyl halide is an ethyl halide and lead tetraethyl is formed.

4. A process as set forth in claim 1 in which the alkyl halide is an alkyl iodide.

5. A process as set forth in claim 1 in which the alkyl halide is ethyl iodide and lead tetraethyl is formed.

6. The process of producing a lead alkyl which comprises forming an electrolyte comprising an emulsion of an alkyl halide, and reducing the electrolyte by an electric current through lead in contact with the electrolyte.

7. A process as set forth in claim 6 in which the emulsion is formed in an alkaline solution.

8. A process as set forth in claim 6 in which the emulsion is formed with casein.

9. The process of producing a lead alkyl which comprises forming an electrolyte comprising an emulsion of an alkyl halide in an alkaline water solution, and reducing the electrolyte by an electric current through a lead cathode.

10. A process as set forth in claim 9 in which the temperature of the reaction mass is maintained slightly below the boiling point of the alkyl halide.

11. A process as set forth in claim 9 in which the alkyl halide is an ethyl halide and lead tetraethyl is formed.

12. A process as set forth in claim 9 in which the alkyl halide is an alkyl iodide.

13. A process as set forth in claim 9 in which the alkyl halide is ethyl iodide and lead tetraethyl is formed.

14. A process as set forth in claim 9 in which an emulsion of an alkyl halide and casein is formed in an alkaline water solution.

In testimony whereof I hereto affix my signature.

BRIAN MEAD.

Since the United States alone has issued 2,185,170 patents (Dec. 31, 1939) in the present series (1836+),[1] a large number of which relate to chemistry and allied subjects, it is evident that this part of the literature is enormous. Interesting statistics are shown in the accompanying table.

NUMBER OF UNITED STATES PATENTS, BY DECADES

Decade	Years	First patent number	Number during decade
1	1836–1846	1	4,347
2	1846–1856	4,348	9,661
3	1856–1866	14,009	37,775
4	1866–1876	51,784	119,857
5	1876–1886	171,641	161,853
6	1886–1896	333,494	219,008
7	1896–1906	552,502	256,116
8	1906–1916	808,618	357,801
9	1916–1926	1,166,419	401,621
10	1926–1936	1,568,040	458,476
11	1936–	2,026,516	

Various schemes of classification—differing in different countries—have been devised to aid the searcher in locating particular patents desired, or in assuring himself that none exist covering a prospective invention. An inspection of our own system[2]—as described in the "Manual of Classification," the semi-annual bulletin of the U. S. Patent Office, and the "Definitions of

[1] For the period 1790–1836, see "List of Patents Granted by the United States, Apr. 10, 1790, to Dec. 31, 1936."

[2] VAN DOREN, *J. Chem. Education*, **6**, 536 (1929); GEIER, *op. cit.*, p. 46.

Revised Classes and Sub-classes"—will impress the chemist that the arrangement is not satisfactory, for his use at least.

The specifications of a patent, including the claim or claims, constitute the information one generally desires. If the patent files are not available, copies of patents may be obtained[1] from the sources, and at the prices, indicated below:

Australian, Commissioner of Patents, Canberra, F.C.T. (1s. 6d.).
Austrian, Österreichisches Patentamt, Vienna (1 S).
Belgian, Ministère des affaires économiques, 19 rue de la Loi, Brussels (not available in printed form).
British, Comptroller-General, Patent Office, 25 Southampton Buildings, Chancery Lane, London W. C. 2 (1s. 1d.—International Money Order).
Canadian, Commissioner of Patents, Ottawa (manuscript or photostat copies only—estimate of price on application).
Danish, Patentkommissionen, Polititorvet 14, Copenhagen (Kr. 3 + postage for each 5 pages or part thereof).
Dutch, Bureau voor den Industrieelen Eigendon, Willem Witsenplein 6, The Hague (fl. 0.50).
French, L'Imprimerie nationale, 27 rue de la Convention, Paris (5 fr. + postage).
German, Reichspatentamt, Gitschiner Str. 97–103, Berlin (M. 0.9).
Hungarian, M. Kir. Szabadalmi Bíróság, Akadémia-utca 12, Budapest V (pengö 1.50).
Japanese, Teikoku Hatumei Kyokai, 10 3-Tyôme, Marunouti Kôzimati-Ku, Tokyo (4 sen + postage).
Norwegian, Styret for det Industrielle Rettsvern, Middelthunsgate 17, Oslo, (Kr. 1.50 + postage).
Russian, Committee on Inventions of the U.S.S.R., Leningrad 11 (25 cents).
Swedish, Kungl. Patent- och Registreringsverket, Stockholm (Kr. 1).
Swiss, Bureau fédéral de la propriété intellectuelle, Berne (fr. 1.20 for each 10 pages).
United States, Patent Office, Washington, D. C. (10 cents).

For purchasing copies of patents issued by the United States, it is convenient to provide oneself with coupons, procurable from the Commissioner of Patents at 10 cents each, on which may be written the necessary data; that is, the number of the patent, the date, the name of the patentee, and the subject of the invention.

In case it is desirable, photostat copies of domestic or foreign patents or other literature available at the U. S. Patent Office, may be obtained at the usual prices—20 cents for a page 8½ by

[1] *Chem. Abs.*, **33**, ii (1939).

11 in. An account may be opened, or estimates obtained in advance.

Bound certified copies of the specifications and drawings of United States patents, as well as patents of certain foreign countries, may be found in some of our larger libraries outside Washington.

Periodicals.[1]—Summarized or abridged information regarding objects or processes patented is issued in a number of periodicals. Three classes of these may be distinguished:

1. General abstracting journals, which include abstracts of many chemical patents (unfortunately not all), in addition to other abstracts, giving the name of the patentee, number of the patent, country, date, and the general nature of the patent. This often constitutes the only information regarding a patent which is published in a chemical journal. If details are desired, one must obtain a copy of the original patent. *Chemical Abstracts, Chemisches Zentralblatt, British Chemical and Physiological Abstracts* (Part B), and *Chemiker Zeitung*, are examples of such publications.

In *Chemical Abstracts* the patents are included in the appropriate sections according to subjects. The countries whose patents are covered (1938) are: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Great Britain, Hungary, Japan, Netherlands, Norway, Russia, Sweden, Switzerland, and the United States.

All British, French, German and United States patents of chemical interest are covered either by abstracts or by titles and references to previous abstracts (used when the subject has been previously patented in another country and an abstract published). For each of the other countries listed only those chemical patents are reported which have been issued to individuals or companies resident in that country or in a country not in the list and which have not been found to correspond to patents previously issued in any other country in the list.

The dates which accompany abstracts of patents are for the most part those used by the U. S. Patent Office in citing the patents as references. These are: Australia* (Accepted), Austria (Ausgegeben), Belgium* (Délivré), Canada* (Issue), Denmark (Bekendtgjort), France (Publié), Germany (Ausgegeben), Great Britain* (Complete specification accepted), Hungary (Megjelent), Japan (Granted), Netherlands (Uitgegeven), Norway (Offentliggjort), Russia (Vydannaya), Sweden (Offentliggjort), Switzerland (Veröffentlicht), United States (Issue).

[1] See HOHENHOFF, "Bibliography of Journals, Books, and Compilations (American and Foreign) Which List and Abstract Patents" (1936).

These are for the most part actual or approximate publication dates. For the countries marked with an asterisk the publication date is not conveniently ascertainable (e. g., does not appear on the face of the patent); the date used, however, usually is not far from the publication date. Belgian and Canadian patents are not printed. Date of issue and date of publication are identical for most countries, or nearly so. Application dates were used in abstracts for certain countries up to July 20, 1933. The dates as given are more useful for reference purposes (more helpful in the library and in ordering patent specifications).

The class is indicated for German, Austrian and Swiss patents because of special difficulty otherwise in locating patent specifications in libraries.

In *Chemical Abstracts* may be found the following material relating to the patent given above:

Lead Alkyls.—B. Mead, U. S. 1,567,159, Dec. 29 (1925). Pb is placed in contact with an aq. emulsion of EtI or other alkyl halide (which may contain casein) and the reaction mass thus formed is subjected to reduction, *e.g.*, by electrolysis, to produce finally, Et_4Pb or the like.

2. Journals on industrial chemistry, which contain notices, abstracts, or reviews of the more important patents, along with occasional discussions of general interest in patent practice.[1] In this case all chemical patents are not included, but only those considered as being of most importance; the information is correspondingly fuller.

3. Special journals on patents, which are made up of material devoted exclusively to patents, designs, trade-marks, and matters relating to them. Sources of information of this type include the official publications of the various patent offices (see Smith's bibliography for a list).

The *Official Gazette* of the U. S. Patent Office,[2] found in the government depository libraries, issued on Tuesday of each week may be taken as an example. In it may be found the following items: condition of pending applications, decisions in patent and trade-mark cases, notices concerning patent suits, interference notices, and abridgments of all patents, giving classification and one or more claims, and trade-marks issued during the week. Wherever possible, drawings are shown. In

[1] See CRANE and PATTERSON, "The Literature of Chemistry," p. 118 (1927); Smith, references on p. 70.

[2] First published in 1872.

addition, monthly alphabetical lists of patentees are published. Particulars for the year's patents are given in the annual report of the Commissioner of Patents, with which is included an index of patentees and inventions (now published separately). By some, the latter is not considered to be an entirely dependable subject index as the alphabetical list is based on titles of patents, rather than on their contents.

For the patent already mentioned the following abridgment appeared in the *Official Gazette* in the issue containing the list of patents granted Tuesday, Dec. 29, 1925:

1,567,159. Method for Producing Lead Compounds. Brian Mead, Boston, Mass., assignor, by mesne assignments, to General Motors Corporation, Detroit, Mich., a Corporation of Delaware. Filed June 14, 1923. Serial No. 645,465. 14 claims.

One figure.

1. The process of producing a lead alkyl which comprises forming an emulsion of an alkyl halide in water, placing lead in contact with the emulsion, and reducing the reaction mass thus formed.

The English *Official Journal* (1889+), the German *Patentblatt* (1877+) with its supplement *Auszüge aus den Patentschriften* (1880+), and the French *Bulletin officiel de la propriété industrielle et commerciale* (1884) are similar publications differing somewhat in details.[1]

Court Records.—Barrows[2] states that

> Valuable information may likewise be obtained from many of the court records of patent cases and even from the court decisions in such cases, inasmuch as a consideration of the patentability, in view of prior patents and publications, is almost always raised in such cases. Extended searches are usually made in connection with such litigation and the pertinent results thereof made a part of the record of the cases. The testimony forming a part of the court records may likewise contain valuable information.

These cases ordinarily involve patentability, infringement, interference, and injunctions.

[1] For further information concerning foreign patents, see ROBERTS, "Guide to Technical Literature," Chap. 6; SEVERANCE, "Manual of Foreign Patents"; and SOULE, "Library Guide for the Chemist," pp. 230–4 (1938).

[2] *Chem. Met. Eng.*, **24**, 517 (1921).

Lists of Patents

In addition to the publications just described, there are available several works which are either indexes to, or lists of, chemical patents. Of these the following are probably most important:

1. *Census Bulletin* 210, U. S. Patents prior to 1902. This was also issued as "Special Reports on Selected Industries," *Census Reports*, Vol. X, Twelfth Census of the United States, Manufactures, Part IV.
2. Yearbook for 1918 of the *Oil, Paint and Drug Reporter*, U. S. Patents granted to Germans and Austrians.
3. Doyle, "Digest of Patents Relating to Coal Tar Dyes and Allied Compounds." This set, planned to be five volumes, covers "All U. S. Patents (to 1924) not only dyes and intermediates, but on methods of dye application as well. A selected group of finished products, other than dyes is also included. Under it are listed explosives, flavors and perfumes, medicinals, photochemicals, plastics and tanning."
4. Friedlander, "Fortschritte der Teerfarbenfabrikation und verwandter Industriezweige." This work covers all branches of synthetic coal tar chemistry for German patents issued since 1877. The complete text is given, including subject, patentee, and numerical indexes, together with a collective numerical index of preceding volumes in each of the later volumes beginning with Vol. IV. Seventeen volumes cover the period 1877 to 1930.
5. Winther, "Patente der Organischen Chemie." This work includes German patents from 1877 to 1905 on dyestuffs and other organic chemicals along with separate lists of patents on organic chemistry from 1895 to 1908 for the United States, Great Britain, France, Austria, and Russia.
6. Bräuer and D'Aans, "Fortschritte in der anorganisch-chemischen Industrie." For inorganic chemistry this work is comparable to Friedlander's, covering the period 1877 to 1938.
7. Worden, "Chemical Patents Index." Worden's compilation, in five volumes includes the chemical subject matter of the 398,377 U. S. Patents granted during the 10-year period 1915 to 1924, of which 22,882 patents have been exhaustively indexed, together with the reissues.
8. "Index to Chemical Foundation Patents." The Chemical Foundation has made available an index of 40,000 references to its patents. These include patentees, assignees, chemicals, processes, apparatus, uses, and patents of this and other countries.
9. Lange, "Die Zwischenprodukte der Teerfarbenfabrikation." This is a summary of the patented methods for making aromatic intermediates.
10. Randall and Watson, "Finding List for United States Patent, Design, Trade-mark, Reissue, Label, Print, and Plant Patent Numbers."

11. Other lists. A number of other lists are available in books, periodicals, and other publications, in the form of bibliographies, as a part of the discussion of some special topic. Examples of these may be found in the following works:
    Bedford and Winkelmann, "Systematic Survey of Rubber Chemistry."
    Ellis, "Synthetic Resins and Their Plastics."
    Hemming, "Plastics and Molded Insulation."
    Worden, "The Technology of Cellulose Esters."

Making Patent Searches

The various indexes and lists of patents just described, together with the various abstracting journals (see Chap. VI) and publications of the patent offices, are very valuable for making patent searches. By means of the patentee, subject, and numerical indexes one can very often determine if the patent is of interest. Copies can then easily be obtained from the U. S. Patent Office. There are probably just as many cases where the abstract is so brief that the significance of the patent is very uncertain.

If a really comprehensive search of the patent literature is to be made, however, it is probably best to avail oneself of the facilities of the U. S. Patent Office itself. This, of course, necessitates one's going there or delegating the search to someone else. One well-known chemist has stated that

> . . . it is, as a rule, advisable to confide this (the search) to some well-known reputable patent attorney, not only versed in patent law, but also possessing more than a passing acquaintance with chemistry, since the methods employed for locating foreign and other patent references call for specialized training.

Searching Facilities at the U. S. Patent Office.—In an article discussing the patent literature as a source of information Smith states[1] that,

> For searching purposes, the most important patents are those of the United States, Great Britain, Germany and France. Switzerland and Austria come next. Dutch, Scandinavian, British colonial and Japanese printed specifications are less important but not to be forgotten. They are given a minor rating for two reasons: first, they are not numerous, and second, many of them are duplications from larger countries. The common practice of patenting valuable inventions in many countries is responsible for much duplication.

[1] *Chem. Met. Eng.*, **34**, 160 (1927).

To the searcher, the one vital feature of patent publications is the manner in which they are classified or indexed. The U. S. Patent Office has an elaborate classification which is constantly being revised. It is essentially a functional classification; that is, first consideration is given to the function performed by a device and not to its structural, physical or chemical features. The classification of a given patent is based solely on the claims; but there is a system of copious cross references to guide the searchers to like patents in other classes and to matter appearing in specifications but not in claims.

Searchers in the U. S. Patent Office have access to files of printed specifications arranged according to this classification. The *Annual Report* of the Commissioner of Patents includes an index of patentees and assignees, and a title index in which entries are made from the leading word of the patent title. As a subject index, this is worth hardly anything. Therefore, as far as Patent Office publications are concerned, the searcher must rely on classification. This has its advantages, and searching is greatly facilitated by the cross references; but there is the inherent disadvantage of all classifications in the fact that many patents are capable of being classified in more than one way. This compels the searcher to go through all the subclasses in which his topic might appear.

The British classification is much simpler. It also is largely functional but does not adhere strictly to that idea. To search British patents solely by classes would be comparatively tedious; but the Office has been diligent in providing other searching aids. These include the "Subject Matter Index," going back to 1617; the numbers prior to 1884 are mostly out of print and can be consulted only in libraries. Then there is the "Fifty Years, Subject Index," from 1861 to 1910, in 271 parts for the 271 sub-classes. These may be had at 6d. each. From 1911 on there are annual subject indexes, not classified; and in each current year quarterly subject indexes are issued. An additional searching aid is the series of "Illustrated Abridgments of Specifications." For each of nine periods from 1855 to 1908, these occupy 146 volumes corresponding to the 146 divisions of the old classification. The revised classification is in 271 parts, so there are 271 volumes after 1908. Classified abridgments are easier to search than complete specifications; but the limitations imposed by the necessary omission of detail must be duly considered.

The German classification is somewhat more elaborate than the British, but much simpler than the American. It has been adopted by several patent offices in the smaller countries. A translation appeared some years ago as a U. S. Government document; and the British Patent Office has published a "Key to the Classifications of the

Patent Specifications of France, Germany, Austria, Netherlands, Norway, Denmark, Sweden and Switzerland."

In reviewing official journals, such as the U. S. *Official Gazette*, to find patents of probable interest, the reviewer must keep in mind the universal desire of inventors to get as much protection as possible. This desire gives rise to the custom of couching patents in general terms, in order to cover all the ground the Patent Office will allow. Thus, a jointed doll becomes an articulated toy; a vacuum tube is an electron discharge device; a child's scooter is a two-wheeled vehicle, etc. By reason of this custom, the specific purpose of a patent is often totally concealed in the title, and may be difficult or impossible to find in the abridgment. Sometimes the illustration tells the secret; or there may be a clue in the name and business of the assignee, or even in the inventor's address. Thus, a patent from Detroit is likely to have an automotive slant; and one from Akron is almost sure to have some relation to rubber, oatmeal or fishing tackle. When the official journal gives no clue, it becomes necessary to refer to the printed specification and drawings to ascertain the specific nature of the invention.

For some special fields of invention there are unpublished unofficial guides which supplement the functions of the official publications. Chemical technology is particularly well equipped in this respect. In the field of mechanical inventions, on the other hand, the main reliance must be placed on searching the classified specifications, or the indexed abridgments, themselves. As pointed out by a former patent examiner, this difference is a natural consequence of the inherent difficulty of searching chemical patents which, unlike mechanical inventions, cannot be illustrated by drawings.

One of the principal aids to chemical searching is to be found in the U. S. Patent Office. This is the chemical card index, started in 1899 by Dr. A. E. Hill of the corps of examiners. It contains over a million cards, from patents and the general literature of chemistry, divided into a subject index and a formula index. Unfortunately it was discontinued in 1919 (see Chap. VIII).

There is also the card index of E. C. Worden, a consulting chemist of Millburn, N. J. This index was described by Payne in *Chem. Met. Eng.*, **32,** 17 (1925). It has about two million cards, showing all the occurrences of every chemical substance mentioned in United States patents from 1900 to date.[1]

In addition to the classified patents, other valuable facilities are available at the Patent Office. Concerning these, Barrows[2] states that

[1] See Chap. VIII, Card Indexes.

[2] *Chem. Met. Eng.*, **24,** 517 (1921).

In making searches at the Patent Office at Washington, not only does the searcher have available the classified patents (U. S.), but he has access to the files of such patents containing the various Patent Office proceedings leading up to their grant, including the original application papers and amendments thereto, and the official communications of the examiners who examined the application, in which are references to the prior patents and publications which the examiners found on their search and considered relevant to the invention sought to be patented. By examining the files of U. S. patents which are of nearest subject matter to the investigation in question, it may be possible to obtain reference to prior patents or publications which are of particular interest and which would not be readily available elsewhere.

A further value of the patent files is the indication therein of the classification of the respective patents and the indication in the various official actions of the classification of the prior patents which are referred to therein. Attention may thus be directed not only to prior patents of relevant subject matter, but even to other classes of the Patent Office which might otherwise have been overlooked but which may contain patents of interest. The number of classes and subclasses is so great and the classification of patents is in many instances so complex that relevant classes or subclasses may well be overlooked unless special precautions are taken to insure their proper consideration.

Likewise available at the Patent Office, (in addition to approximately three million patents of about fifteen other countries), are the records of interference proceedings in which issued patents have been involved—records which in some cases contain lists of prior patents and publications relating to the same subject matter as the patent, in others testimony of interest in connection with the patented invention.

In conclusion, Smith states that

The searcher who can go to the Patent Office has every advantage. The large and comprehensive library of the Patent Office provides the necessary technical literature and works of reference; complete classified files of United States patents are available; and there is a nearly complete collection of the printed specifications and official publications of all the patent offices of the world. The chemical card index has already been mentioned. Experienced translators are at hand, to iron out difficulties with foreign patents, even in the uncommon and lesser known languages. And last but not least, the searcher has at his service one of the leading technical libraries of America. When a desired reference is not to be found in the Patent Office, it can generally be located in one of the numerous scientific and technical libraries of government departments and bureaus in Washington.

Excepting for the classified files of United States patents, searching facilities are nearly as good in and around New York City. The New York Public Library has the printed specifications of several countries, and official journals of several more. It also has a splendid reference library; and so have the Chemists' Club and the Engineering Societies. Worden's chemical card index, previously mentioned, is not far from New York City.

Smaller patent collections may be found in the public libraries of most large cities, in some of the state libraries and the larger universities, and in certain institutional libraries. Notable among these are the collections of the Franklin Institute in Philadelphia and of the State Historical Society in Madison, Wis.

References on Patents

BARROWS, *Chem. Met. Eng.*, **24,** 516 (1921). Patents.

DELLER, "Principles of Patent Law for the Chemical and Metallurgical Industries" (1931).

GEIER, "Patents, Trademarks and Copyrights" (1930).

HOAR, "What a Business Executive Should Know about Patents" (1926).

KEIPER, "Pioneer Inventions and Pioneer Patents" (1923).

KEYES, *Chem. Met. Eng.*, **29,** 405 (1923). Applying for a patent.

LINLEY, "Practical Advice to Inventors and Patentees" (1925).

MARX, *Chem. Age*, **31,** 393 (1923). Chemical patent searches.

MÜLLER, "Chemie und Patentrecht" (1928); "Chemie und kontinental Patentrecht" (1932).

POTTS, "Patents and Chemical Research" (1921); "Patents, Invention and Method" (1924).

REVISE, "The Preparation and Prosecution of Patent Applications" (1933); *Ind. Eng. Chem.*, **23,** 580 (1931). What is patentable in industrial and engineering chemistry.

RHODES, "Patent Law for Chemists, Engineers and Executives" (1931).

ROSSMAN, "The Law of Patents for Chemists" (1934); *J. Chem. Education*, **9,** 486 (1932), What the chemist should know about patents.

SADTLER, *Ind. Eng. Chem., News Ed.*, **16,** 190 (1938), Foreign patents on chemical inventions (working requirements and costs).

SMITH, *Chem. Met. Eng.*, **34,** 160 (1927), Patent literature as a source of information; *Ind. Eng. Chem.*, **16,** 527 (1924), Patent reference sources.

THOMAS, "The Law of Chemical Patents" (1927); *Ind. Eng. Chem.*, **19,** 176, 315, 426 (1927), An outline of the law of chemical patents.

UNTIEDT, *Ind. Eng. Chem.*, **21,** 689 (1929), Some aspects of chemical patent searches.

U. S. Patent Office, "General Information Concerning Patents."

VAN DOREN, *J. Chem. Education*, **6,** 536 (1929), Organization of the Patent Office.

WRIGHT, "Inventions, Patents and Trade-marks—Their Protection and Promotion" (1933).

CHAPTER V

ORIGINAL SOURCES—MISCELLANEOUS CONTRIBUTIONS

In the pages of good books lie the magic to inspire our dreams and the power to make those dreams come true.

There are still a few types of publications hardly belonging in the previous sections. The number of these is not large, and often the material included in an individual publication is not extensive; but the information may be distinctly important, and they should not be overlooked.

Dissertations.—Generally the candidate for the doctorate degree (Ph.D. or Sc.D.) is required to publish his dissertation and to present a specified number of copies to the library of the institution granting the degree. In some cases the entire dissertation may be published in a journal. Then reprints of the article are accepted as fulfilling the requirement. In these instances the information included may be found in the proper journal. Very often, however, the detailed account of the work involved is so long that only lengthy abstracts or abridgments giving the most important contributions are published as articles in journals. Even these may not be published. In such instances, one must obtain a copy of the original dissertation, if the details of the work are to be consulted.

These publications are not easy to locate. So far as the author is aware, no general list of them is available; and references to them are seldom included, even by title, in the abstracting journals. If a copy is in a given library, this will be shown, of course, by the card index or catalogue. Frequently, one only learns of their existence through references to them in articles or in special bibliographies.

Bolton has compiled a bibliography of academic dissertations, extending from 1492 to 1897, which is published as *Smithsonian Publication* 1253 (see chapter on bibliographies). This list

includes the titles of the many dissertations for the period covered which are in the Library of Congress. Several other sources of information are available. Since 1912, the Library of Congress has issued an annual "List of American Doctoral Dissertations." The National Research Council has published some lists, in the Reprint and Circular Series, under the title, "Doctorates Conferred in the Sciences by American Universities." Beginning with 1933, the H. W. Wilson Company has printed "Doctoral Dissertations Accepted by American Universities." For some years an annual list for chemistry appeared in the *Journal of Chemical Education*. Palfrey and Coleman have compiled a "Guide to Bibliographies of Theses." There have been some titles of doctoral dissertations appearing in the appropriate sections of *Chemical Abstracts*. For France there is the annual "Catalogue des thèses et écrits académiques," and in Germany the annual "Jahres-Verzeichnis an der deutschen Universitäten erscheinenen Schriften."[1]

Generally in such lists one finds only the title, and every experienced searcher knows how noncommittal these designations may be. At best, a brief abstract or digest may be included. In using the lists one may find that some dissertations are listed under the name of the institution granting the degree.

Recently an international committee has urged educational institutions to see that copies of all theses interesting to chemists are filed with the International Office of Chemistry in Paris and with Science Service, Washington, D. C., so that these two centers may be fully developed as sources of copies through microfilms of the documents. It is planned to have the journals concerned announce the existence of such documents, indicating the document number, pages, and price on 35-mm. film.

The following list includes examples of some typical titles of dissertations:

Lee, "A New Precision Method for Determining the Densities of Liquids," New York University (1913).

Mcgrail, "The Reactions of Calcium Carbide with the Vapors of Certain Organic Compounds," Catholic University of America (1916).

Loomis, I. "A Study of the Hydrogen Electrode, of the Calomel Electrode, and of Contact Potential." II. "The Application of the Hydrogen

[1] Some European publishers sell collections of dissertations on selected subjects, such as inorganic analysis.

Electrode to the Measurement of the Hydrolysis of Aniline Hydrochloride, and the Ionization of Acetic Acid in the Presence of Neutral Salts," Johns Hopkins University (1911).

Nevins, "The Amino Acid Content and Nutritive Value of the Proteins of Cottonseed Meal," University of Illinois (1921).

Manufacturer's Technical Bulletins.—It is the usual custom for manufacturers of material and equipment used in scientific and technical work to issue circulars or pamphlets dealing with the construction and use of new apparatus, appliances, materials, and processes. These bulletins serve not alone as advertisements. There is often included a valuable summary of the theory of the construction and operation, if the matter relates to scientific apparatus, together with the directions for using the apparatus for its intended purpose. Lists of the more important journal references relating to the apparatus and its applications may be included.

It is well to remember that such publications, along with current advertising, constitute the latest published announcements of producers. Trade catalogues, such as the "Chemical Engineering Catalog," are primarily compilations of selected technical bulletins, often for annual distribution. Obviously, the catalogue material may not be up to date.

These publications are not filed in most libraries. Ordinarily, the best way to obtain late copies is to write the concerns advertising in periodicals or taking space in trade catalogues. In some cases, a permanent mailing list is maintained upon which one may have his name placed, thus insuring the receipt of the latest bulletins. At the present time, notices of a number of new bulletins appear in the News Edition of *Industrial and Engineering Chemistry*, and in *Chemical and Metallurgical Engineering*, indicating the nature of the contents of the publications, and the address where copies may be obtained.

Vilbrandt[1] has suggested a systematic scheme for cataloguing such engineering trade literature according to unit operations.

The following list includes the titles of typical bulletins of this class:

"Alcoa Aluminum and Its Alloys," Aluminum Co. of Am.

"Zinc and Its Corrosion Resistance," Am. Zinc Inst.

[1] *J. Chem. Education*, **10**, 354 (1933).

"Bethlehem Alloy Steels," Bethlehem Steel Co.
"Corrosion and Heat Resisting Steels," Crucible Steel Co.
"Dowmetal," Dow Chem. Co.
"Quenching," E. F. Houghton Co.
"Optical Methods," Adam Hilger, Ltd.
"Modern pH and Chlorine Control," W. A. Taylor Co.
"ABC of Hydrogen Ion Control," LaMotte Chem. Products Co.
"Data Concerning Platinum," Baker and Co.
"Polarigraphic Analysis," E. H. Sargent Co.
"Hydrogen Ion Concentration Measurements"; "Electrical Conductivity Measurements"; "The Electro-Chemograph"; "The White Potentiometer," Leeds and Northrup Co.

CHAPTER VI

SECONDARY SOURCES—PERIODICALS AND SERIALS

All that mankind has done, thought, gained or been—it is lying, as in magic preservation, in the pages of books.—*Carlyle.*

The various types of publications already considered constitute what have been termed the "primary" sources of chemical information. This does not imply that they are of greater importance than those which remain to be discussed. The intention is rather to include in these classes those publications which, as a rule, contain material that is new, or at least previously unpublished. From our consideration of the nature, number, and variety of these primary sources, it is evident that the facts relating to some given subject will, in all probability, be widely scattered, and, as a consequence of this, be difficult to locate when needed. In other words, the material included in these publications is necessarily unorganized. At the present time the separate and distinct published chemical items of some significance—that is, papers, bulletins, patents, and others—must number several million, when we reflect that *Chemical Abstracts* contained over 65,000 separate abstracts in 1938.

The publications to be considered in this chapter, together with those following, have been termed "secondary" sources, since they contain information compiled from one or more of the original sources and arranged according to some definite plan. This material, then, is essentially organized in its nature. The general object in issuing such publications is to provide means for collecting, classifying, arranging and discussing the scattered myriads of facts already recorded, so that the most efficient use may be made of the results of others' work. These secondary sources have been grouped as periodicals and serials, bibliographies, general works of reference and textbooks, and miscellaneous compilations, the first of which will now be considered.

Periodicals and Serials

With the rapid increase in the number of publications listed as original sources, together with the accompanying extension in the amount included in them, it became very desirable—in fact, a necessity, if one is to keep informed of the developments in even a limited field—to have some agency for collecting, classifying, and summarizing this material as soon as possible after its appearance. No individual, or even small group of individuals, is at present capable of performing such a task. Comprehensive efforts in this direction are limited, therefore, almost exclusively to scientific societies.

Depending upon the information furnished, and upon the method of arrangement used, the periodicals supplying this kind of information have been grouped under the headings of index serials, abstracting journals, and review serials. These will be considered separately.

Index Serials

Index serials contain compilations of references only, including author's name, title of article, and the reference to the original. Their general function is to serve as an index by means of which one may easily find scientific papers.

Some individuals may be inclined to put index serials and bibliographies in the same class. In the sense that they are both lists of references, this is justified. The two have been separated, however, upon the general basis that index serials are periodical publications and are devoted to some general field of scientific endeavor. Bibliographies, on the other hand, are not periodical publications, and they relate to some specific subject in one field of science.

There seems to be no index serial devoted to chemistry alone. Since the boundaries of chemistry, as well as other sciences, are more or less vague, and since these publications cover science in general, or some broad technical field, a search through them may be valuable when made in connection with a search in abstracting journals. Several index serials will be considered briefly.

Catalog of Scientific Papers.—(1800–1900; name changed in 1900 to *International Catalog of Scientific Literature.*) The

Royal Society had under way what was termed the "most comprehensive index to general science ever attempted." Although a number of volumes were issued, publication of the work ceased.

Repertorium der technischen Journal-literatur.—Appearing first as an annual publication in 1874, the *Repertorium der technischen Journal-literatur* had been issued previously, under the name of *Repertorium der technischen Literatur* prior to 1879, in three volumes covering the period back to 1823. The German Patent Office has issued it since 1877. Many references are included, the arrangement being alphabetical by subjects. Over 400 periodicals were covered (discontinued 1908).

Engineering Index.—The serial, *Engineering Index,*[1] is one of technical, industrial, and commercial nature, giving title and reference to papers. Papers are grouped alphabetically by subjects, but the title appearing under a subject may not fully represent the subject matter of the article. It is valuable for information on costs and finance, and management of industrial concerns. Its particular interest is in connection with technical and engineering subjects, so that one may expect to find some information relating to certain phases of applied chemistry.

From 1884 to 1905 four volumes were issued; since that time the index has been an annual publication. Most of the journals covered are in the English Language. (See page 269 for *Engineering Index Service.*)

Industrial Arts Index (1913–).—Independently published by H. W. Wilson Company, New York, the *Industrial Arts Index* is issued in magazine form as an indexing service to various technical journals, mostly American, which are selected by the subscribers as the leaders in their respective fields. The entries deal with technical articles, and descriptions of new apparatus and machinery, relating to engineering, electrical appliances, chemistry, business, printing, and textiles, and are arranged alphabetically, by subject, under sufficient subject headings to bring out the points of interest.

Agricultural Index (1916–).—The H. W. Wilson Company also publish the *Agricultural Index*, which is a monthly subject index to agricultural periodicals, publications of the U. S.

[1] Different names have been used.

Department of Agriculture, and of American state and foreign agricultural experiment stations, and, occasionally, other literature.[1]

Index Medicus (1879–).—This index, covering current medical literature, may be of much value to the biochemist.

Reader's Guide (1900–).—Articles of a popular nature, appearing in nonchemical periodicals, may be found through the *Reader's Guide*.

Abstracting Journals

Abstracting journals may be designated as publications giving contemporaneous, concise summaries of the various articles, bulletins, patents, and other contributions already mentioned.

Each abstract ordinarily furnishes the following information: title of original contribution abstracted, author's name, original reference (that is, number and designation of a bulletin; abbreviation, series, volume, page, and year of journal; name of patentee, country, date, and number of a patent; or other suitable means to enable one to locate the original), and usually a brief summary of the main points or results brought out in the paper. With the constant increase in the number of items to be abstracted, the present tendency is to omit the summary for some of the less important ones.

Crane and Patterson[2] state that

> The ideal abstracting journal (1) covers its field completely (2) publishes good annual and collective indexes (3) maintains a high quality in its abstracts, and (4) keeps its service prompt. All are important but it is believed that completeness and the publication of good indexes are of the most consequence. Completeness depends to some extent on the quality of abstracts for an abstracting journal is not complete, even though it reports every paper appearing in its field, if the abstracts are inadequate, and an index to serve as a thorough guide to the literature must be based on abstracts which are complete from the indexing point of view. If completeness is attempted and safeguarded by an abstracting journal it can be used with a feeling of reasonable assurance that the search has been thorough.[3]

[1] Crane and Patterson, "The Literature of Chemistry," p. 198 (1927), mention other less important or highly specialized indexes.

[2] "The Literature of Chemistry," p. 78 (1927).

[3] See Bradford, *Chemistry & Industry*, **56**, 947 (1937), on the coverage of scientific and technical literature by abstracting and indexing periodicals.

Publications constitute not only a means of communicating ideas but also a barrier between a discoverer and the potential user of the discovery. Generally the discoverer, as author, bears the responsibility of describing adequately his contribution. At this point the abstractor begins. Assuming that he fully comprehends the significance of the publication, the quality or value of the abstract depends very largely upon his skill in preparing an adequate summary.[1] In many cases he decides that the title is sufficient to indicate the probable value of the reference. Papers in foreign languages, and especially those in rare and inaccessible periodicals, are usually abstracted in more detail.

Next, the indexer has an important function to perform, for the compilation of an adequate and accurate index for the abstracts is second only in importance to the preparation of the abstract itself. Since one depends so much upon indexes in looking for material, an index must be dependable if nothing is to be missed. Finally the searcher must have the perseverance and ingenuity to find what has been written, abstracted, and indexed. His problem is discussed more fully in Chap. X.

One very serious, and possibly insurmountable, difficulty connected with all abstracting journals is the failure to list or index what may be termed hidden facts. Unfortunately, titles, and indexes, often give no adequate indication of the nature of the material presented in a publication, and one is dependent upon the abstractor's judgment as to what should be mentioned in the abstract. It frequently happens that dependence upon indexes causes one to miss important points. This will be mentioned again in a later section. But so far as their indexes are accurate, abstracting journals do enable one to ascertain what general references are available upon a given subject, and where the original may be found, if details are desired. Frequently, of course, the information contained in the abstract is all that is required.

In connection with abstracts, borderline publications present at least two problems. The first concerns the editor of the

[1] See CRANE, "In the Abstract," *Ind. Eng. Chem., News Ed.*, **16**, 353 (1938). For the aid of abstractors, the editor of *Chemical Abstracts* provides detailed directions, available in pamphlet form, covering the preparation of abstracts.

abstracting periodical, who must decide whether the publication has sufficient chemical interest to warrant abstracting and indexing. The second concerns the searcher, who obviously can not find the item in a given abstracting journal if no abstract was prepared. As an example we may consider analytical balances and spectrophotometers, both instruments being the product of the physicist and of primary theoretical interest to him from the standpoint of mechanics and optics, respectively. Probably all new items on balances will be abstracted, since every chemist is familiar with the instrument. Certain analysts may be just as much interested in a new spectrophotometer, but even yet there is no assurance a publication on it will be included. The worker in this field must watch suitable sources in physics as well as chemistry.

Abstracting all publications of chemical interest, or even most special fields, has become an undertaking of such magnitude that only an organization, such as a chemical society, can do it. Some of the larger chemical manufacturing firms have their library operate a private abstracting service. Generally the abstracts include only those thought (usually by the librarian) to be of interest to the research staff, and they are likely to be more detailed than those otherwise available.

Between the time of publication of an item in an original source and the appearance of an abstract of it there is an inevitable time lag, usually not less than 2 to 3 months or more than 1 year. Most delay is likely to be encountered in the rarer foreign periodicals. Abstract editors strive for promptness, but the distribution, writing, and printing processes take time.

Journals Publishing Abstracts.—Abstracts appear in two kinds of journals: those devoted exclusively to abstracts, and those whose contents consist partly of abstracts and partly of other items, mentioned when discussing periodicals in Chap. II. The second type is found particularly in publications devoted to special fields; here, as one might expect, the abstracts are selected upon the basis of their importance to those engaged in the special work. Some of the more important general abstracting periodicals will now be considered briefly.

Chemical Abstracts.—Our own *Chemical Abstracts* will be considered first as it is devoted exclusively to this type of publi-

cation, and it is the most comprehensive periodical of its kind now appearing, considered from the standpoint of the number of abstracts and the sources of abstracts covered. Started in 1907 by the American Chemical Society to replace the *Review of American Research* (1897–1906), it appears on the tenth and twentieth of each month, with the issues of Dec. 10 and 20 devoted, respectively, to the annual author and subject indexes. In 1921 a formula index was added, covering both inorganic and organic compounds, and in 1935 a numerical patent index. A staff of 1 editor, 6 associate editors, 54 assistant editors, and about 450 abstractors cooperated in producing it in 1939.

Occasionally a list is published giving the sources from which abstracts are taken. In 1936 this list[1] contained 2808 separate entries,[2] and included for each publication, so far as possible, the name, frequency of appearance, number of volumes per year, present volume number (1936), price, place of publication, and libraries in this country where it may be found. In addition to the annual and decennial indexes, individual issues carry author indexes.

In compiling the material, the field of chemistry has been divided, as shown in the table below, into 30 classes, for each of which one or more assistant editors are responsible. This enables one having special interests to locate easily the references bearing upon his specialty. In each section one may expect to find, in the order given, general abstracts, cross references to other sections, notices of new books, and abstracts of patents. To facilitate finding a reference upon a given page[3] which has been located in the index, a small exponent is given for each page (or column) indicated. This exponent shows the nearest ninth of the page, counting downward, on which the abstract will be found. Abbreviations may be found at the end of the subject-index volume.

Decennial indexes have appeared regularly. Users of the periodical should familiarize themselves with the introductory

[1] See *Chem. Abstracts*, **30**, 8693 (1936).

[2] This number exceeded 3000 by 1940.

[3] Since 1934 a two-column page has been used and the index figures refer to the separately numbered columns.

sections of the decennial, and subsequent annual subject indexes being examined. In addition to the general explanatory material, any changes from previous practice are noted.

STATISTICS FOR 1938

Division	Abstracts of papers	Abstracts of patents		
		Abstracts	Pages	Abstracts
Apparatus, plant equipment, and unit operations	38.9	820	59.0	1734
General and physical chemistry	280.6	3870	0.1	3
Subatomic phenomena and radiochemistry	158.5	2652	3.7	67
Electrochemistry	53.1	727	56.2	1213
Photography	19.8	276	36.3	446
Inorganic chemistry	34.1	385		
Analytical chemistry	104.0	1286	0.9	20
Mineralogical and geological chemistry	89.1	1418		
Metallurgy and metallography	186.8	2710	81.6	1884
Organic chemistry	617.2	3142	80.6	1316
Biological chemistry	876.8	12403	1.6	29
Foods	144.9	1761	15.8	333
Chemical industry and miscellaneous industrial products	46.9	997	123.9	2087
Water, sewage, and sanitation	64.9	1025	10.5	255
Soils, fertilizers, and agricultural poisons	184.0	2265	12.5	270
Fermentation industries	33.3	472	7.9	170
Pharmaceuticals, cosmetics, and perfumes	83.1	1231	46.2	762
Acids, alkalies, salts, and other heavy chemicals	23.8	431	44.5	887
Glass, clay products, refractories, and enameled metals	47.9	854	36.0	874
Cement and other building materials	39.6	551	19.8	431
Fuels, gas, tar, and coke	74.4	1085	37.2	810
Petroleum, lubricants, asphalt, and wood products	59.2	871	78.6	1159
Cellulose and paper	71.4	881	49.2	1018
Explosives and explosions	11.0	174	8.0	176
Dyes and textile chemistry	65.8	1050	130.1	1967
Paints, varnishes, and lacquers	42.1	705	21.7	410
Fats, fatty oils, waxes, and soaps	43.4	547	11.7	211
Sugar, starch, and gums	29.8	458	5.6	123
Leather and glue	23.4	308	9.9	203
Rubber and allied substances	56.5	562	30.8	657
Totals	,604.3	45,917	1,019.9	19,515
Book, journal, and thesis titles	33.5	1,496		
Headings, blanks, and cross references	119.0			

Chemisches Zentralblatt.—Beginning in 1830 as the *Pharmaceutisches Zentralblatt* (continued to 1849 under this name, then

changed to *Chemisch-Pharmaceutisches Centralblatt,* again in 1856 to *Chemisches Centralblatt,* and, finally, in 1897 to *Chemisches Zentralblatt*), this periodical is probably our most important abstracting journal because of the length of time covered. For years there was no other devoted to abstracts alone, and we must of necessity use it if abstracts are desired for general material appearing during this early period. Many of the individual abstracts are considerably more detailed than those in *Chemical Abstracts.* It appears weekly, and at present consists of two volumes per year. References to it usually have the form *Chem. Zentr.* 1928 II, 789, or simply *C* instead of *Chem. Zentr.* Prior to 1919 no attempt was made to cover applied chemistry thoroughly.[1] At present the material appears in 8 main divisions, the last, applied chemistry, having 20 subdivisions.

The periodical is now published by the Deutsche Chemische Gesellschaft. Some special features may be noted: the use of italics for the names of new compounds; a brief outline at the beginning of the volume for each division of chemistry covered; a list of numbers of patents mentioned; and statistical data on the abstracts included in the various divisions. Collective indexes are available, with the recent subject volumes using a classified rather than alphabetical arrangement.

British Chemical and Physiological Abstracts.—The two journals just described are the only current ones devoted entirely to general abstracts, but there are a considerable number which contain abstracts along with other material. Two of these deserve special attention on account of their general nature.

Probably the foremost examples of this type of publication are the British periodicals, the *Journal of the Chemical Society* and *Chemistry & Industry* (name changed in 1924 from the *Journal of the Society of Chemical Industry*). Abstracts were first included in the former journal in 1871, and a separate volume was devoted to them for the first time in 1878. From then until 1926 the even-numbered volume for each year was devoted to abstracts on general, physical, and organic chemistry. The latter journal was started in 1882, as the *Journal of the Society of Chemical*

[1] For early industrial abstracts see *Angew. Chem.* and *Chem.-tech. Übersicht* (of *Chem. Ztg.*).

Industry, and from the beginning has included abstracts on all phases of applied chemistry.

Beginning with 1926 the Bureau of British Chemical Abstracts combined the abstracting work of the two journals and issued *British Chemical Abstracts*, Part A, pure chemistry, being bound separately and Part B, applied chemistry, being bound as part of the *Journal of the Society of Chemical Industry*. Now the material is being issued as *British Chemical and Physiological Abstracts* in the following parts: Part A, pure chemistry; Section 1, general, physical, and inorganic chemistry; Section 2, organic chemistry; and Section 3, physiology and biochemistry; Part B, applied chemistry (including patents).

The four divisions, Part A, Sections 1, 2, and 3, and Part B, are all separately paged; but the general index, covering both Parts A and B and bound in each part, indicates the division in which to look. The index is arranged by authors, subjects, patent numbers, and journals abstracted. At present (1939) Parts A 1, A 2, A 3, and index are bound as two volumes of *British Chemical and Physiological Abstracts*, and Part B is bound as Part 2 of *Chemistry & Industry*.

Taken together these two journals enable one to follow abstracts in the English language back from 1907, the beginning of *Chemical Abstracts*, to the dates indicated. In general, the abstracts are well written, but *Chemical Abstracts* covers more periodicals. Most of the patents covered are included in the section on applied chemistry.

Bulletin de la société chimique de France.—This French journal first included abstracts in 1863. Since 1892, abstracts constitute one of the two annual volumes. Now this volume is known as the "Documentation" section. French abstracts on applied chemistry since 1919 have appeared in *Chimie & industrie*.

Other Sources of Abstracts.—The publications mentioned above are considered best for general work. Abstracts are widely scattered, however, since many periodicals have contained such information for at least part of the period covered by the journals. In case the periodical was not restricted in its field, its abstracts are general in nature; but if it pertained to some special field, the abstracts are confined to this and closely related fields. The latter arrangement is the more

common, and forms a desirable combination for the individual who wishes to watch developments only in his own limited field.

As there are no outstanding points of difference between these publications and those already discussed, the accompanying list has been arranged to show some of the other sources of a limited number of abstracts.[1]

General Chemistry:

1789–1870 *Annales de chimie et de physique.*
1820–1931 *Dinglers Polytechnisches Journal.*
1832–1860 *Annalen der Chemie.*
1834–1873 *Journal für praktische Chemie.*
1840–1858 *The Chemist.*
1842–1859 *The Chemical Gazette.*
1860–1932 *Chemical News.*
1867–1896 *Berichte der deutschen chemischen Gesellschaft.*
1879–1905 *Journal of the American Chemical Society.*
1887– *Bulletin de la société chimique de Belgique.*
1901–1918 *Revue générale de chimie pure et appliquée—Répertoire.*
1921– *Japanese Journal of Chemistry.*
1925–1939 *Journal of Chemical Education.*

Agricultural Chemistry:

1872– *Zentralblatt für Agrikulturchemie* (Biedermann).
1889– *Experiment Station Record.*

Analytical Chemistry:

1862– *Zeitschrift für analytische Chemie.*
1877– *The Analyst.*
1896– *Annales de chimie analytique et de chimie appliquée.*
1908– *Annales des falsifications et des fraudes.*

Biochemistry:

1900– *Centralblatt der experimentelle Medizin.*
1902– *Berichte über die gesamte Physiologie und experimentelle Pharmakologie.*

[1] NOTE.—For a more extensive list, see the following publications: *Bulletin National Research Council*, Vol. I, No. 3, "Periodical Bibliographies and Abstracts for the Scientific and Technological Journals of the World"; Carnegie Library Publications (Pittsburgh), "Technical Indexes and Bibliographies," appearing serially; Crane and Patterson, "The Literature of Chemistry," p. 91 (1927); Reid, "Introduction to Organic Research," p. 92 (1924); Rimbach, "How To Find Metallurgical Information"; West and Berolzheimer, "Bibliography of Bibliographies on Chemistry and Chemical Technology," p. 12 (1925).

1916– *Physiological Abstracts.*
1927– *Biological Abstracts.*

Food Chemistry:

1882– *Zeitschrift für Untersuchung der Lebensmittel.*
1889– *Experiment Station Record.*
1891– *Zeitschrift für Fleisch- und Milchhygiene.*
1891–1922 *Hygienische Rundschau.*
1908– *Annales des falsifications et des fraudes.*
1931– *Nutrition Abstracts & Reviews.*

Mineralogical and Geological Chemistry:

1807– *Zentralblatt für Mineralogie, Geologie und Paläontologie in Verbindung mit dem neuen Jahrbuch für Mineralogie, Geologie und Paläontologie.*

Organic Chemistry (see Journals on general chemistry).

Pharmaceutical Chemistry:

1809– *Journal de pharmacie et de chimie.*
1830– *American Journal of Pharmacy.*
1841– *Pharmaceutical Journal.*
1851–1911 *Proceedings of the American Pharmaceutical Association.*
1912–1934 *Yearbook of the American Pharmaceutical Association.*
1928– *Squibb Abstract Bulletin.*
1935– *Pharmaceutical Abstracts.*

Physical Chemistry:

1877–1919 *Beiblätter zu den Annalen der Physik.*
1889–1904 *Zeitschrift für physikalische Chemie.*
1896–1906 *Journal of Physical Chemistry.*
1898– *Science Abstracts* (Part A).
1903–1912 *Journal de chimie physique.*
1906– *Kolloid-Zeitschrift.*
1920– *Physikalische Berichte.*

Technological:

1871– *Journal of the Iron and Steel Institute.*
1882– *Chemisch-technische Übersicht* (of *Chem. Ztg.*).
1884– *Journal of the Society of Dyers and Colourists.*
1887–1918 *Zeitschrift für angewandte Chemie* (now *Angew. Chem.*).
1898– *La revue des produits chimiques.*
1898– *Journal of the Chemical, Metallurgical and Mining Society of South Africa.*
1904– *Revue de métallurgie.*
1906– *Journal of the American Leather Chemists' Association.*
1908– *Transactions of the Ceramic Society (London).*
1908– *International Sugar Journal.*

1909– *Journal of the Institute of Metals.*
1911– *Zeitschrift für Metallkunde.*
1914– *L'industrie chimique.*
1917– *American Dyestuff Reporter.*
1919– *Chimie & industrie (Extraits de chimie).*
1919– *Giornale di chimica industriale ed applicata.*
1919– *Journal of the American Water Works Association.*
1919– *Journal of the American Ceramic Society (Ceramic Abstracts).*
1920– *Brennstoff-Chemie.*
1921– *Transactions of the American Society for Metals.*
1934– *Metals & Alloys (Metallurgical Abstracts).*

Review Serials

A third type of periodical is given over to brief accounts of the developments in various fields for some given period of time. These accounts are really annual reviews of progress, and the publications are known as review serials. The method of compilation usually consists in having some one familiar with a given field examine the papers, and other contributions, relating to this field, and then prepare a summary stating the general trend indicated by the developments during the year, and noting any particular advances made. References to the more important papers are usually given.

That the significance of such reviews was realized early in the development of modern chemistry, is indicated by the establishment of such a publication in 1795. With the facilities now available, one familiar with index serials and abstracting journals should be able to compile his own report of progress, or at least a non-critical summary; but it is often a very distinct advantage to be able to find such a review already written.

Several sources of reviews are available. A few of them will now be considered, the order being based upon the time of their appearance.

1821–1849, Berzelius, *Jahresberichte über die Fortschritte der physischen Wissenschaften* (later *der Chemie*).—This serial was the first of its kind, excepting the *Berlinisches Jahrbuch*, and was very valuable for investigators working during the time covered. Where investigations take one back to the literature of that period, it is still of distinct service. In 1849 the material was classified under *Anorganische Chemie*, *Pflanzen Chemie*, and *Tier Chemie*. The index is not satisfactory.

1847–1910, Liebig and Kopp, *Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, Physik, Mineralogie und Geologie.*—Issued by different editors and varying somewhat in nature, this serial was for years the main source of critical summaries on the important advances in the fields covered. In 1847 the division of material was as follows: physics and physical chemistry; inorganic, organic, analytical, and technical chemistry; mineralogy, and chemical geology. The early indexes are not satisfactory, but this defect was later corrected with the publication of collective indexes.

1855– , Wagner, *Jahresbericht über die Leistungen der chemischen Technologie* (issued under different names for some years).—The contents of about 200 journals are summarized in this serial. A classified arrangement is used with the material on organic and inorganic chemistry in separate volumes.

1891–1918, Meyer, *Jahrbuch der Chemie* (Bericht über die Wichtigsten Fortschritte der reinen und angewandten Chemie).—Seventeen divisions are included (1915), with many subdivisions indicated. Original references and subject and author indexes are given.

1892– , *Mineral Industry.*—The publication known as *Mineral Industry* is an annual review of the mining and metallurgical industry, including statistics, and an account of the year's technical progress.

1904– , *Annual Reports of the Chemical Society* (London).—The annual reports on the progress of chemistry are divided into the following classes: general and physical chemistry; inorganic chemistry; organic chemistry, aliphatic, homocyclic, and heterocyclic divisions; analytical chemistry; physiological chemistry; agricultural chemistry and vegetable physiology; crystallography and mineralogy; subatomic phenomena and radioactivity. Author and subject indexes are given, together with a list of journals and abbreviations covered.

1907– , *Science Progress.*—This is an English publication, issued quarterly, devoted to reviews of the various fields of science.

1916– , *Applied Chemistry Reports* (of the Society of Chemical Industry).—An excellent series of annual reports on the progress of applied chemistry is given. The general scheme of arrangement is the same as that used in the abstracts section

of *Chemistry & Industry*. Original references, author and subject indexes are given.

1926–1935, *Survey of American Chemistry*.—This represented an undertaking of the National Research Council. The aim was to present an annual review of the progress in pure and applied chemistry in the United States.[1]

Other Review Serials

1795–1840 *Berlinisches Jahrbuch für die Pharmacie.*
1811–1833 *Jahrbuch der Chemie und Physik.*
1830– *Neues Jahrbuch für Mineralogie, Geologie und Palāontologie.*
1849–1855 *Annual Report of the Progress of Chemistry and Allied Sciences.*
1858– *Jahresbericht über die Fortschritte auf dem Gesammtgebiete der Agrikulturchemie* (Hoffmann).
1860–1892 *Jahresbericht über die Fortschritte der Agriculturchemie* (Berlin).
1863–1892 *Chemisch-technisches Reportorium.*
1865–1892 *Jahrbuch der Erfindungen und Fortschritte auf den Gebieten der Physik und Chemie, der Technologie und Mechanik, der Astronomie und Meteorologie.*
1866– *Jahrbuch der Pharmacie.*
1871–1918 *Jahresbericht über die Fortschritte der Tier-Chemie* (Maly).
1874–1883 *Jahresbericht über die Fortschritte auf dem Gebiete der reinen Chemie.*
1879–1885 *Fortschritte der Chemie* (Köln).
1881–1905 *Technisch-chemisches Jahrbuch* (Biedermann).
1890– *Jahresbericht über Gärungs-Organismen* (Koch).
1894–1909 *Jahrbuch der Elektrochemie und angewandten physikalischen Chemie.*
1899–1918 *Répertoire générale de chimie pure et appliquée.*
1902– *Ergebnisse der Physiologie.*
1905– *Fortschritte der Chemie, Physik und physikalischen Chemie.*
1908–1932 *Jahrbuch der organischen Chemie.*
1920– *Jahrbuch der chemisch-technische Reichanstalt.*
1920– *Jahrbuch der Physiologie und experimentelle Pharmakologie.*
1921– *Physiological Reviews.*
1931– *British Plastics Yearbook.*
1932– *Annual Review of Biochemistry.*
1932– *Ergebnisse der Enzymforschung.*
1938– *Ergebnisse der Vitamin-und Hormonforschung.*
1939– *Annual Review of Physiology.*

For others, see *Bulletin of the National Research Council*, Vol. I, No. 3, "Periodical Bibliographies and Abstracts for the Scientific and Technological Journals of the World"; and Crane and Patterson, "The Literature of Chemistry," p. 135 (1927).

[1] In the *American Yearbook* (T. Nelson & Sons) may be found a review of American achievement for a few chemical subjects.

CHAPTER VII

SECONDARY SOURCES—BIBLIOGRAPHIES

Before starting an experiment, I always read everything available on the subject and on related matters.—*Thos. A. Edison.*

A résumé of the literature of the problem in which he is interested is the first need of every research worker in the field of chemistry and chemical technology, as well as in other fields of science. To meet this need, it is necessary either to find or to compile a partial or complete list of references relating to the subject. Such a list is known as a bibliography. Although a completed bibliography may bear a close resemblance to a page of an index serial, several points in connection with their compilation, publication, and use seem to warrant a separate treatment.

As an indication of the importance of bibliographies in consulting work, A. D. Little stated that

The compilation of bibliographies forms a very important part of our work. When a new subject comes up for investigation, the library is requested to compile a list of references to the important literature on that subject . . . Experience teaches that the chemist prefers personally to examine and digest the list on a subject under investigation, rather than to have someone else do it for him.

A carefully prepared bibliography aids greatly in enabling one to determine what has already been done on a given subject, and thus to build on the knowledge already accumulated by others. Many chemists do not realize how much useful information is practically lost to them owing to the scattered manner in which it reaches the world. Too many diligent investigators spend valuable time and effort rediscovering facts, recorded years before the time of their work.

Scope.—Bibliographies may be either partial or complete (as it is possible to make them). In the latter case, everything found relating to the subject is included, while in the former case some limitation is set in the compilation, such as language, country,

journals, books, patents, authors, time covered, uses of material, preparation of substances, or other similar schemes.

Information Included.[1]—In the usual bibliography, part or all of the following information is given for each entry: author's name; title of publication; some statement, in addition to the title, indicating the exact location in the publication of the material cited (the last includes for a book the volume, page, and year, or number of the edition; for a patent, the name of the country issuing the patent, the number, and the date; for a public document, the name of the division issuing the document, together with proper designation, number and date; and for a journal article, the title of the article, series, volume, page, and year); and an annotation indicating the nature of the material to be found in the source to which reference is made. If the bibliography is a separate publication, preferably all the above information should be included. If it is a part of a book, often the author's name, together with some statement regarding the contents, occurs in the body of the discussion. Annotations are the exception except in separately published bibliographies. Regardless of the part of the above data included for a given entry, whatever is given is usually spoken of as a reference.

Whatever data are given for the reference or citation, they should indicate unmistakably the essential points of those mentioned above, such as volumes and pages; but, at the same time, they should be as brief as possible in the interest of efficiency in reading, proofreading, writing, and preventing error. Unfortunately, the literature of chemistry abounds in annoying examples of digression from this general principle. As instances of this kind, one needs mention only such things as the use of Roman numerals, the inclusion of the number of the issue for the ordinary chemical journal, the omission of the year, or more serious yet, the omission of the series. It is a matter not only of confusion in the older literature, but also of lack of uniformity in present practice. There are still many writers who disregard the excellent procedure followed by the editors of *Chemical Abstracts*. As an example of what is still happening in scientific publications, two citations are quoted from a recent article[2]

[1] MELLON, *Proc. Indiana Acad. Sci.*, **37**, 83 (1927).

[2] *Science*, **62**, 419 (1925).

calling attention to some desirable reforms. These two refer to the same article but appeared in different periodicals: (1) *Ann. Appl. Biol.*, (**24** (1923). No. 2. pp. 151–193, pls. 3, figs. 31); and (2) *Ann. Appl. Biol.* **24**: 151–193, 3 pl. 31 fig. 1923. The second contains 16 less characters without sacrificing anything in essential information.

The following examples[1] seem adequate forms, respectively, for (*a*) periodicals, (*b*) institutional publications, (*c*) patents, and (*d*) books (including manufacturer's technical publications and doctoral dissertations):

a. SMITH, *Ann. chim. phys.*, [9], **25**II, 481 (1912); BROWN, *J. Chem. Soc.*, **1930**, 450–92.

b. WILLIAMS, *Bur. Mines, Tech. Paper* **135**, 40 (1920).

c. JONES, U. S. Patent 1,729,300 (Feb. 4, 1929).

d. FRIEND, "Textbook of Inorganic Chemistry," **9**I, 381–9 (1920). Griffin, London; LANGE, "Handbook of Chemistry," p. 31 (2d ed.).

Arrangement.—A bibliography is essentially only a list of references, with no specification regarding the arrangement of the separate entries in the list. Although a list not systematically arranged is to be preferred to none at all, the advantages resulting from the adoption of a definite order are well worth the extra time and effort required to put the references in this form. An examination of the bibliographies published each year reveals a wide variation in their usefulness owing to the kind of data included, or to the arrangement used, or to both. An outstanding example of a poor publication of this kind may be found in a bibliography of over 400 pages, including hundreds of entries, published by a national society. Because of its unsatisfactory arrangement, very much of the possible usefulness of this collection of facts is practically lost, although much time and considerable expense were required for making it.

For most bibliographies, one of the following schemes may be followed in listing references:

1. According to the order in which the references are mentioned in the text. Although this scheme is used in some important works of reference[2] and in many scientific papers, one must

[1] MELLON, *Proc. Indiana Acad. Sci.*, **40**, 57 (1930).

[2] MELLOR, "Treatise on Inorganic and Theoretical Chemistry." ABEGG, "Handbuch der Anorganischen Chemie."

ordinarily read more or less of the accompanying discussion in order to obtain the significance of any given citation. Each entry generally includes the name of the author and data for locating the material to which reference is made.

2. Alphabetically according to the name or title of the publication containing the contributions. This is one of the least satisfactory schemes, but it may be used when the author's name is omitted.

3. Chronologically. This scheme may be desirable in some cases, especially if the time of publication of the contributions is an important point, as in patent searches.[1] It serves also to indicate the historical development of the subject. The various references occurring under the same year may be given a serial number.[2] They may also be arranged alphabetically by authors under each year.[3] In any chronologically arranged bibliography the subdivision by years should be prominent on the page. The succession of years may be forward or backward.

4. Alphabetically by authors. This is the most used system, and, in the opinion of the author, it is the best for most purposes. The following three variations in this kind of arrangement may be mentioned:

a. A simple alphabetical list is made, with or without a serial number for each entry. This is satisfactory for short lists but not when the number of entries is large,[4] since too much time is then required to ascertain whether a reference to some specific point is included.

b. The arrangement is the same as in *a*, including the serial number, but with the addition of a comprehensive subject index. The latter is prepared on the basis of the material contained in each entry, and so arranged that the numbers, under any given heading in the index, indicate the serial numbers of the references in which this subject is treated.[5]

[1] ST. JOHN, *Science*, **70**, 217 (1930).

[2] HOWE, "Metals of the Platinum Group," *Smithsonian Pub.* 1084.

[3] WEST, "Vitreous Enameling of Iron and Steel."

[4] BRANNER, "A Bibliography on Clays and the Ceramic Arts."

[5] VAN PATTEN, "Bibliography on Corrosion"; WEST and GILMAN, "Organomagnesium Compounds in Synthetic Chemistry."

c. The references are first classified,[1] some procedure such as the following being used: according to the nature of the publication in which the references occur, as periodicals, public documents, patents (subdivided according to countries), and books; according to some special viewpoints of the author; or according to the natural subdivisions or particular phases of the subject with which they deal. They are then arranged alphabetically in each of these divisions. As in *a*, they may or may not be numbered. Even in a classified bibliography a good subject index is of value.

The following classification, used by Schrero in his bibliography on "Water Glass," illustrates the advantage of this system:

Bibliography.
Patent literature.
History.
General.
Properties.
Manufacture.
Applications:
  General and miscellaneous.
  Agglutinants:
    General and miscellaneous.
    Abrasives.
    Cements.
  Detergents:
    Analysis.
  Egg preservation.
  Glass and ceramics.
  Medicine and surgery.
  Paper.
  Structural materials:
    General and miscellaneous.
    Artificial stone.
    Concrete.
    Fireproofing-preservation of wood.
    Paints and preservative coatings.
    Textiles.
Analysis.

In Doty's bibliography on "Selenium," the references are first classified and then arranged chronologically in each division.

[1] BORGSTROM, BOST, and BROWN, "Bibliography of Organic Sulfur Compounds."

Finally, for each year the authors are listed alphabetically. Author, patentee, and subject indexes make the publication readily usable. An arrangement devised by the author[1] for a bibliography covering methods used in determining the composition of amalgams illustrates the application of a different scheme to a special case.

For general, and more or less extensive, bibliographies, the arrangements mentioned in 4*b* and 4*c* seem the most useful, particularly if annotations are included; that is, critical statements of the content and value of the material contained in each publication listed. In locating, for example, the references dealing with the corrosion of copper alloys in a general bibliography on corrosion, one would turn in the former case directly to the index and look for the words alloy and copper. In the latter case it would be necessary to locate the division dealing with copper alloys. Probably in most cases an individual using such a bibliography wants information only for special purposes and consequently is not interested in reading through even 50 articles to find that the valuable material is contained in some three or four which might have been immediately evident in a well-arranged bibliography. If the list has no such arrangement, he must examine all references given in order to select the desired ones, or to assure himself that there are none of value included.

Place of Publication.—Unless one's problem is very specialized, or of very recent interest, the chances are that, somewhere, there are lists, more or less complete, bearing directly or indirectly upon the subject. Difficulty may be encountered, however, in finding them. They appear either as separate publications, or in connection with some other publication, such as treatises, encyclopedias, monographs, journal articles, or bulletins. Those appearing separately are usually either more or less general in nature, or contain many entries, while the shorter ones appear in connection with a chapter in a book or at the end of an article.

Although bibliographies are widely scattered, and in many cases can be found only after long searches, there are several publications available which are valuable aids in such work. Some of these are included in the following list:

[1] MELLON, *Proc. Indiana Acad. Sci.*, **34**, 157 (1925).

1. Bolton, "Select Bibliography of Chemistry."—In the preface it is stated that

> An attempt has been made in the following pages to collect the titles of the principal books on chemistry published in America and Europe from the rise of the literature to the close of the year 1892. The term chemistry is taken in its fullest significance, and the bibliography will be found to contain books in every department of chemical literature, pure and applied.
>
> The bibliography is confined, however, to independent works and their translations.

To facilitate reference, the work is divided into 7 sections: Bibliography; Dictionaries; History; Biography; Chemistry, pure and applied; Alchemy; and Periodicals. The first volume covers the field from 1492 to 1892; while the first supplement takes the literature on to 1897 and includes items omitted from the first volume. Out of about 18,000 titles appearing in these volumes, approximately 375 relate to bibliographies. A third volume comprises a list of academic dissertations printed independently between 1492 and 1897. The second supplement continues the work of the other volumes through 1902.

2. Research Information Service.—The National Research Council, through its Research Information Service, undertook to serve as a clearing house for information of a scientific and technical character, including bibliographies. Most of the projected service of this kind has been abandoned, but the following bibliographical publications of chemical interest were issued:

a. "List of Manuscript Bibliographies in Chemistry and Chemical Technology," 1922, by C. J. West and Callie Hull. This is an alphabetical list, by subject, showing the period covered and approximate completeness of unpublished or manuscript bibliographies which may be used, provided arrangements can be made with the author.

b. "Bibliography of Bibliographies on Chemistry and Chemical Technology," 1900–1924, by C. J. West and D. D. Berolzheimer. This work is the most important bibliographic collection for the chemist and chemical engineer. In its compilation, about 100 periodicals and treatises were searched for lists of references on special topics. The material collected was assembled alphabetically by subject and classified as follows: general

bibliographies, abstract journals and year books, general indexes of serials, bibliographies on special subjects, and personal bibliographies. The first supplement covers the period from 1924 to 1928, and the second, 1929 to 1931.

c. "Classified List of Published Bibliographies in Physics," 1910–1922, by K. K. Darrow.

d. "Catalogue of Published Bibliographies in Geology," 1896–1920, by E. B. Mathews.

CHAPTER VIII

SECONDARY SOURCES—GENERAL WORKS OF REFERENCE AND TEXTBOOKS

Books are the masters who instruct us without rods and ferules, without hard words and anger, without clothes or money. If you approach them, they are not asleep; if investigating you interrogate them, they conceal nothing; if you mistake them, they never grumble; if you are ignorant, they cannot laugh at you. The library of wisdom, therefore, is more precious than all riches, and nothing that can be wished for is worthy to be compared with it. Whosoever therefore acknowledges himself to be a zealous follower of truth, of happiness, of wisdom, of science, or even of the faith, must of necessity make himself a lover of books.[1]—*Richard de Bury.*

As we have seen, the statements of chemical facts, and the theories and discussions involving these facts, are issued first in the publications which have been designated as original sources. The first step in the process of bringing the material from an unorganized to an organized state is taken in the index serials and abstract journals. The work of the review serials follows and is closely related to that of the other two. Likewise, bibliographies are more or less related to index serials.

These organizing agencies, important as their work is, do not bring the material into a readily usable form. They are the reaper which collects the individual stalks of grain and ties it in bundles; but a thrasher or separator is needed to bring the kernels out in a form suitable for ordinary consumption. The separators of chemical literature will now be considered; they constitute the large majority of the so-called "books" on chemistry (not bound periodicals and bulletins) of which we have an extensive collection.

These books touch practically every phase of chemistry and chemical technology and vary widely in quality, dependability,

[1] From "Philobiblon," the first English book on the joys of reading (1344).

usefulness, arrangement, comprehensiveness, and the kind of information included. The quality and dependability of a book depend largely upon the perspective and discernment of the author. In connection with dependability, it should be kept in mind that such works are not published frequently, and the information in many cases, therefore, is not up-to-date. The arrangement, comprehensiveness, and kind of information included are decided upon by the author; but he is guided in this case by the objective for which the book is produced.

The usefulness of books depends upon various circumstances; but their general value has been well summarized by Crane and Patterson[1] who state that such works

> . . . introduce the novice to the general field of the science, or some part of it, explain new theories in the light of already known facts, and help to coordinate and systematize knowledge. They furnish information, exhaustive or not, in a form adapted to quick reference, and guide the searcher back to the original sources by means of citations. Historical works record the development of the science, popular books initiate the public into its mysteries and elicit interest and support, and treatises on the chemical arts give the reader the benefit of long experience or of the combined researches of many workers. Who shall say that the chemist can depend on journals alone? The mere fact that over a thousand new books of chemical interest are published annually proves the demand for them.

An attempt has been made to classify the book literature into several more or less distinct groups upon the basis of the general nature of the information included in them. In considering each of these groups, the general plan of this book will be followed—that of describing the nature or characteristics of the group, and then giving typical examples, or listing the more important or representative contributions. The latter point will be carried a little further in this chapter, since it seems wise to mention some of the works in the special fields of chemistry.

WORKS OF REFERENCE

The first general division of books to be considered includes the publications usually spoken of as works of reference. They may be specialized and limited presentations related to some narrow phases of work; or the treatment may be sufficiently comprehen-

[1] "The Literature of Chemistry," p. 12 (1927).

sive and exhaustive to involve a whole field of chemistry. They are the works to which one turns when in need of either specific facts or comprehensive discussions involving relationships and general significance of facts. Such information is not to be found in the ordinary textbook, except in the case of a few well-known facts.

A reference book,[1] in the strict sense of the term, is a book to be consulted for information on a definite point rather than to be read through . . . In a broad sense, any book may be considered a reference book if it contains a great deal of information arranged in an easily accessible form.

Reference books[2] are the clearing houses of knowledge. They are libraries in miniature, focusing into a single book information scattered through a thousand volumes. They are short cuts to learning, pass keys to the accumulated wisdom of the ages.

In the ideal case,[3] a work of reference should not only give the authorities for statements of facts, but it should also indicate what knowledge has been gleaned on the particular subject in question. To do this in a practicable manner, attention must be directed to the original publications on the subject. This naturally makes the work of compilation extremely laborious; in some cases, indeed, it happens that scores of independent references are involved in the statement of one particular fact.

These works of reference, depending upon the general arrangement and manner of presenting the material, may be roughly subdivided into three groups: indexes; handbooks and treatises, including dictionaries and encyclopedias; and monographs. Each of these groups will now be considered in turn.

A. Indexes

The amount of information available in these works of reference is so large that it has been found desirable to have means at hand by which one may get easily to that part of the stock of facts dealing with a given subject. To meet this need, various

[1] Hutchins, Johnson, and Williams, "Guide to the Use of Libraries," p. 66 (1925).

[2] Jordan, *Literary Era*, **8**, 52 (1901).

[3] Mellor, "Treatise on Inorganic and Theoretical Chemistry," **1**, viii (1922).

indexes have been compiled whose primary use is to get one quickly and directly to the desired goal.

The information furnished in compilations in the form of indexes includes, frequently, a few common facts for each item, but the most important value of such works lies in the directions given for finding the publications which contain the detailed information. These directions usually consist of references to articles in periodicals or to bulletins, patents, or other sources. Such compilations are available in the form of card indexes or indexes arranged as books.

1. Card Indexes.—Card indexes are those in which each item listed is entered on a separate card, the cards being arranged alphabetically by subjects or authors, or numerically. They are, of course, unpublished, and, consequently, inaccessible except to those who are situated, or can go, where they are located.

In some instances one may take advantage of the service rendered by some agency which is located conveniently to the index. This was one of the services maintained by the Research Information Service of the National Research Council which offered unusual opportunities. Situated in Washington, its personnel was in touch with the possibly unequalled facilities offered in the Library of Congress, the Smithsonian and Carnegie Institutions, the Patent Office, the Surgeon General's Office, the various governmental bureaus, and several scientific societies.

A decided advantage of this form of index is its adaptability. It may be kept strictly up-to-date by the simple and easy process of putting in another card for each new item as it appears.

Unfortunately, adequate card indexes are relatively rare. The average library has one showing the books and periodicals to be found on the shelves and in the stacks, but that is about all. Only an occasional index can be found which deals with references on a specific subject. Many industrial establishments undoubtedly have such indexes compiled for their own special purposes, but ordinarily these sources of information are not open to the public.

Among the card indexes which have been compiled, that at the U. S. Patent Office stands out as the preeminent one. Since an understanding of its arrangement is necessary both for searches at the U. S. Patent Office and in the empirical formula index of

Chemical Abstracts,[1] a brief description of the system is given here.

Devised by Hill[2] for the Classification Division of the U. S. Patent Office, and later adapted for use in *Chemical Abstracts*,[3] the scheme is essentially an index of chemical compounds by their empirical formulas rather than by their names. It covers both organic and inorganic compounds and is used as follows: reject the water of crystallization and rewrite the empirical formula in the alphabetical order of the chemical symbols, except that in carbon compounds put carbon first and hydrogen second; look in the proper alphabetical location in the index, noting the first symbol of the rewritten formula, together with the number of times it occurs. Further details (water of hydration and polymers) may be found in *Chemical Abstracts*.[4]

According to this arrangement, one would find the following compounds listed under the formulas shown: rubidium permanganate—MnO_4Rb, ammonium sulfate—$H_8N_2O_4S$, and acetyl bromide—C_2H_3BrO.

By 1920 over 1,000,000 cards had been entered at the U. S. Patent Office; but, unfortunately, at that time the work had to be discontinued, because of insufficient funds.

Another card index, of distinct value to those within reach of it, is that at Millburn, N. J.,[5] where the E. C. Worden Laboratory and Library has a card index of approximately 4,500,000 cards (1939) covering general chemical technology of the United States, Great Britain, France, and Germany. It is especially rich in references to United States patents issued since 1900.

2. Indexes in the Form of Books.—Card indexes may be said to be in manuscript or unpublished form. In contrast to these, we have published indexes which appear in the form of bound books.

Such indexes have a defect common to most scientific books—that of becoming rapidly out-of-date. A distinct advantage, as compared with card indexes, lies in the fact that a published book is susceptible of easy distribution, and can, therefore, be made accessible in many places.

[1] Beginning with 1922.

[2] *J. Am. Chem. Soc.*, **22**, 478 (1900); **29**, 936 (1907); **34**, 416 (1912).

[3] CRANE and HOCKETT, *Chem. Abstracts*, **14**, 4557 (1920).

[4] *Ibid.*, **21**, 5345 (1927).

[5] *Chem. Met. Eng.*, **32**, 17 (1925).

Indexes of this type are designed to cover their field to the date of their own publication, or to some other specified date. The arrangement and general nature of the publications vary somewhat. Several specific ones will be discussed, and distinctive points noted in connection with each.

The compilations known as formula indexes are possibly the most detached type of book index. They are usually considered as a means of getting to more extensive information, but in indicating known compounds they are sufficient in themselves. Such works are frequently very desirable. The name of a compound, particularly if it has a complicated structure, may be unknown to the searcher, or at least uncertain; but there is only one empirical formula. Knowing this, he can turn to the formula index and get started at once.

Hoffmann, "Lexikon der anorganischen Verbindungen."—Hoffmann's "Lexikon" is stated to be a complete list of all analytical and synthetic inorganic compounds known at the time of its compilation (April, 1909).[1]

The elements are listed in the order of nonmetals, light metals, heavy metals, and the argon group, each element being given a number, as indicated below.

1. H	17. Li	33. As	49. Tb	65. W
2. O	18. Rb	34. Sb	50. Er	66. V
3. Cl	19. Cs	35. Bi	51. Yb	67. U
4. Br	20. Ca	36. Ti	52. Sc	68. Ta
5. I	21. Sr	37. Ge	53. Tm	69. Cb
6. F	22. Ba	38. Zr	54. Dy	70. Au
7. S	23. Ra	39. Sn	55. B	71. Pt
8. Se	24. Be	40. Th	56. Al	72. Ru
9. Te	25. Mg	41. Ce	57. Ga	73. Rh
10. N	26. Zn	42. La	58. In	74. Pd
11. P	27. Cd	43. Nd	59. Mn	75. Ir
12. C	28. Pb	44. Pr	60. Fe	76. Os
13. Si	29. Tl	45. Sm	61. Co	77. He
14. NH_3	30. Cu	46. Eu	62. Ni	78. Ne
14*b* NH_4	31. Ag	47. Gd	63. Cr	79. A
15. K	32. Hg	48. Y	64. Mo	80. Kr
16. Na				81. Xe

[1] From this date to 1922, when the formula index of *Chemical Abstracts* begins, there is no systematic compilation of inorganic compounds by formulas.

The elements are taken up in their serial order, as given in the table, the element itself being considered first. Then come the compounds between it and the preceding elements, in the reverse order; that is, number 17, for example, is listed, then compounds of number 17 with number 16, followed by those containing numbers 17 and 16 and some preceding element. Others follow in a similar manner.

In using the index one may find a given compound by following the steps indicated: (*a*) establish a rough formula, omitting the water of crystallization; (*b*) from the table obtain the number for each element—for sulfuric acid H = 1, S = 7 and O = 2; (*c*) arrange the formula according to descending order of the numbers —for sulfuric acid it is 7, 2, 1 or SO_4H_2; (*d*) locate the formula in the index by looking under the element having the highest number—for sulfuric acid look under sulfur. Also the compound may be found from the alphabetical list of formulas in Vol. III, the entry being under the symbol appearing first in the alphabet.

Under each formula the following information is generally given, in the order indicated: the ordinary formula (or optional formula), name of the compound (or element), references to journal articles (author and journal), references to Gmelin-Kraut's "Handbuch," (the symbol N.: is followed by the volume, part, and page for the 7th German ed.); and a statement of the color, crystalline form, or physical state of the substance.

The volumes are arranged as follows:

Vol. I_I (1917) Introduction; general remarks; elements 1 to 31 (H to Ag).
Vol. I_{II} (1919) Elements 32 to 55 (Hg to B).
Vol. II (1912) Elements 56 to 81 (Al to Xe); list of bibliographies.
Vol. III (1919) General information; periodicals; abbreviations. . . .

Richter (*M. M.*), "*Lexikon der Kohlenstoff-Verbindungen.*"—This work of Richter is to organic chemistry what the work of Hoffmann is to inorganic, a formula index to all compounds known at the time of publication, Dec. 31, 1909. The last edition (third) lists over 144,000 compounds.

The compounds listed are arranged according to their molecular formula, water of crystallization being neglected. The details of arrangement, as described in the work, are as follows:

1. Formulas are divided into groups according to the number of carbon atoms present. All compounds containing one carbon atom are listed first—the "C_1-Gruppe."

2. Formulas of each group are divided into classes on the basis of the number of elements, in addition to carbon, contained in the compound. In the "C_1-Gruppe" are listed first all compounds containing one element other than carbon, the "C_1-Gruppe mit einem Element." Then follows the "C_1-Gruppe mit zwei Elementen," and so on through all compounds containing only one carbon atom.

3. Formulas are arranged in each group in alphabetical order, according to the elements present. The alphabet of the system, or the succession of the elements combined with carbon as determined by the frequency of occurrence, is not the ordinary alphabet, but one worked out by Richter. Its order is *C, H, O, N, Cl, Br, I, F, S, P,* and then the others in ordinary alphabetical order from *A* to *Z*, according to symbols.

4. Formulas are arranged finally according to the number of atoms of each element which, in addition to carbon, are contained in the compound. All compounds containing 2 carbons and 2 hydrogens are considered before those containing 2 carbons and 3 hydrogens.

Suppose one is looking for information on ethyl cyanide, C_2H_5CN. The formula is arranged, as noted above, in the form C_3H_5N. There will be found at the top of the pages Arabic and Roman numerals, which serve as a guide. The former indicates the number of carbon atoms in the formulas listed on the page, and the latter indicates the number of other elements combined with the carbon. In our case, one would turn to the page with 3 II upon it and look for the formulas with 5 hydrogens and 1 nitrogen.

The percentage composition is given for the more important compounds. All isomers are listed separately, as 1), 2). . . . For each there is given the preferred German name, often another recognized name, statement of physical state or M.Pt. or B.Pt., salts formed, reference to original paper or papers, including reference to the *Zentralblatt* in many cases, and for many of the compounds a reference to the third edition of Beilstein's "Handbuch der organischen Chemie." The Roman numeral is for the volume (asterisk signifies supplement) and the Arabic numeral for the page. If a reference to Beilstein is not given, the compound is not described in the third edition.

The work contains the references to the papers which describe the methods of preparation of the compounds and their properties, as well as those which deal with the immediate changes which they undergo. No reference is made to purely theoretical papers, nor to those with analytical, physical, mathematical,

crystallographic, and medicophysiological contents. A name index is given in Vol. IV. In the second edition there is given, in a separate table, the percentage composition of the compounds listed, about 90,000. This table is now issued as a separate publication. For many years several important foreign periodicals have indexed organic compounds according to the Richter system, and it is used in the formula index for the fourth edition of the Beilstein treatise.

Stelzner, "Literatur-Register der organischen Chemie."—The formula index of Richter, third edition, brings the literature of organic chemistry up only to 1910. The fourth edition of Beilstein, discussed in the next section, comes to this point also. To provide a compilation giving references to the voluminous literature on the subject since that date, the Deutsche Chemische Gesellschaft issued the *Literatur-Register der organischen Chemie* under the editorship of Stelzner. Five volumes cover the period 1910 to 1921.[1]

The compounds are listed by formula, as in Richter's "Lexikon," and under each the references are arranged according to the following outline, which serves to classify them on the basis of the material included.

Historical, constitution, configuration.
Occurrence, mode of formation, preparation (isolation, purification).
Analytical (methods of estimation, separation, analysis).
Physical properties and reactions (influence on the properties of other bodies).
Chemical behavior (reactions, transformation).
Physiological behavior.
Technical use.
Salts, esters, compounds with other materials.

A statement is given in connection with most of the references indicating the main point of the paper. Certain physical constants are given. In the back of the volumes there is included an index of names, with their Richter formula.

Heilbron, "Dictionary of Organic Compounds" (1934–1938).—This compilation, the first of its kind in English for organic chemistry, was designed to list "the constitution and physical and chemical properties of the principal carbon compounds

[1] Since 1921 this work has been superseded by the formula indexes of *Chemisches Zentralblatt.*

and their derivatives, together with the relevant literature references." The three volumes include an estimated 60,000 compounds.

The arrangement is alphabetical according to the names of the compounds. The nomenclature does not follow exclusively any one of the systems now in use. For information on this point and on the general arrangement of the text, the user should consult the introduction in Vol. I.

Rowe, "Color Index" (1924).—Rowe's more specialized compilation is a list of synthetic organic dyestuffs, natural dyestuffs, and natural and artificial inorganic coloring matters. It is comparable to the earlier "Farbstoff-tabellen" of Schultz. The data, presented in tabular form, include the serial number, commercial and scientific names, formula, method of preparation, and significant literature references.

Schultz, "Farbstoff-tabellen" (1929).—Schultz's work, now in the seventh edition, is the best known list of commercially important organic dyes. Supplements bring the information up to 1937.

Patterson and Capell, "The Ring Index."—This compilation consists of some 4000 parent ring systems serially numbered, with structural formulas, numberings, names, and references (including those to the completed volumes of the Beilstein set). The object is to have the serial number serve to identify the ring system; just the serial numbers in the "Color Index" are used to identify dyes. Adequate explanations are included for the naming and classification used.

3. Other Formula Indexes.—There are included in the introduction to the third decennial subject index of *Chemical Abstracts* two special forms of formula indexes as an aid for making effective use of its contents. One of these is an index of organic radicals arranged by empirical formulas, according to the modified Hill system used in *Chemical Abstracts*. It enables one to ascertain quickly an approved name for a radical whose empirical formula is known. Accompanying this index is an alphabetical list of the names of the radicals.

The other special form is known as a ring formula index. By means of this index of ring complexes one learns the name used in the index for the simplest parent compound containing any

particular ring or combination of rings, and by turning to this name in the index he will find the compounds listed, and, perhaps, cross references to names of derivatives.

To illustrate: 6, 6, 6, C_4N_2-C_6-C_6 Benzoquinoxaline
Phenazine

(1) This designates a complex ring of three components, each of 6 members; (2) the first is heterocyclic, containing 4 carbon atoms and 2 nitrogen atoms, and the other two are carbocyclic rings of 6 atoms each; (3) parent compounds of this configuration will be found in the index under the two names given. If derivatives are indexed, a structural formula will be found with the proper numbering and also appropriate cross references to derivatives having other common names, if any such are in the index.

B. Handbooks and Treatises

It has been stated that indexes serve the general purpose of enabling one to find the sources of information relating to a given subject. They are the signposts indicating the way to go.

The sources to which reference is made may be journal articles, bulletins, patents, or other publications. One source which is very valuable for general reference work consists of the more or less exhaustive surveys of available information in given fields. These surveys take the form of tabulated data or general discussions; each of these types will be discussed.

The words "treatise" and "handbook" have been selected as most applicable for designating this type of publication. It is believed that the word "handbook" should properly be applied to the smaller books, such as Olsen's "Chemical Annual" and the "Chemiker Kalender," rather than to works such as Abegg's "Handbuch der anorganischen Chemie"; "treatise," on the other hand, should be used in connection with Abegg's set and with similar publications. The word "compendium" is rather widely used in a sense practically synonymous with treatise. Since the dictionaries give compendium as an abstract or abridgment, this usage does not seem justified.

As errors are noted in a given volume of a set, they are often published as "Errata" in a subsequent volume. Such works

should be examined for these lists. Some librarians make a note of each correction in the appropriate place.

1. Tabular Compilations.—In some phases of chemical work we now have an enormous number of individual facts which, when collected and properly arranged simply as statements of facts, are of frequent and wide use. This material is usually arranged in the form of tabular data and includes such items as atomic weights, molecular weights, boiling and melting points, solubilities, and other physical constants.

There seem to be no distinctive points of difference among the various works of this type, except in the amount and kind of material included, and there is not much tendency to classify the material on the basis of fields of chemistry. The reason, of course, is obvious. The solubility of calcium citrate, for example, may be of just as much importance to the biochemist as to the physical chemist.

Some of the well-known works are described below. Statements are included to indicate the general nature of the contents and to direct attention to any special features.

a. Comprehensive Works.—The large, comprehensive works are designed to include, as far as possible, all the known data of this kind. They usually cite references to the original literature so that one may consult details when it is desirable to know the conditions under which the constant was determined.

Washburn, "International Critical Tables" (1926–1930).—The publication of "International Critical Tables" marked the appearance of the first comprehensive compilation of tabular data in the English language. The material was collected, critically evaluated, and arranged by some 300 chemists, physicists, and technologists in more than a dozen countries.

The program covered all available information of value concerning the physical properties and numerical characteristics of (*a*) pure substances, (*b*) mixtures of definite composition, (*c*) the important classes of industrial materials, (*d*) many natural materials and products, and (*e*) selected bodies or systems, such as the earth and its main physical subdivisions, the solar and stellar systems, and certain biological organisms, including man. Publications in all languages up to 1924 were examined for data, and much unpublished information was collected.

The range of subjects covered and the lack of a logical arrangement of the material in the seven volumes make a concise summary of the contents impossible. Each volume carries an adequate table of contents showing the kind of material included, and many of the sections begin with an outline of their subject matter. Volume VIII is an elaborate index to the set which enables one to locate easily the various types of data. Certain peculiarities of the index are explained in the introduction.

Specific data for a given system may or may not be easily found. In some cases a general formula has to be used to calculate the desired data; in other cases the difficulty comes in interpreting the tabular system used. Often it centers in employing the "key-number" formula for compounds. This "standard arrangement" of data in "A," "A-B," "B," and "C" tables, explained in Vol. I, page 96, and Vol. III, page viii, should be mastered by users of the set.

The principal explanatory text is in four languages: English, French, German, and Italian. Citations to the literature are gathered together at the end of each section where reference is then made to the list of publications at the end of each volume. An introductory paragraph explains the method of handling references. Volume VII gives a complete list of publications cited. It should be kept in mind that the references included are not likely to be later than 2 to 3 years preceding the date of publication of the individual volume consulted.

Landolt-Börnstein, "Physikalisch-chemische Tabellen" (1923).—Until the publication of "International Critical Tables" the "Tabellen" of Landolt-Börnstein was the most comprehensive work of its kind. It was the preeminent source for physicochemical constants and similar data. To the main work, issued in two parts, have been added Supplement I (1927), Supplement II (1931) in two parts, and supplement III (1935–1936) in three parts. The original classification of material in some 30 divisions, given in detail in the table of contents, is followed in the supplements.

In the indexes in the supplements there are included the pages in the previous parts of the set for the same entry. A separate index covers the data for especially important compounds, such as ethanol and ammonia. References to the original literature

are arranged at the end of each section. Year and corresponding volume numbers are given for 103 periodicals. The proportion of German publications in the list is suggestive of the outlook of the compilers.

"Tables annuelles de constants et donnée numérique."—The "Annual Tables," appearing first in 1910, were started to bring together each year all the numerical data published in chemistry, physics, biology, and technology. Although the summaries have not appeared annually nor as promptly as desirable, the results achieved by the international commission are probably all that could be done under the circumstances. The indexes and text for each table are now given in both French and English. Two cumulative indexes (in French) cover the first 10 volumes. Since 1924 this set may be considered as supplementing "International Critical Tables." The years covered by each volume follow:

I (1910); II (1911); III (1912); IV (1913–1916); V (1917–1922); VI (1923–1924); VII (1925–1926); VIII (1927–1928); IX (1929); X (1930); XI (1931–1934); XII (1935–1936); XIII (1937–); XIV (193 –).

Comey-Hahn, "Dictionary of Chemical Solubilities" (1921).—This compilation includes all analyzed inorganic substances, with original references given under the individual entries. An explanatory preface is included.

Seidell, "Solubilities of Inorganic and Organic Compounds" (1919).—Information is included in this work concerning the sources of solubility data, the methods of calculating them to desired terms, the interpretation of their tabular arrangement, as well as some of the methods used for the accurate determination of solubilities. Volume II (1928) supplements Vol. I to 1927.

For each table the author and year of his publication are given. By referring to the author index, the journal reference may be found.

Egloff, "Physical Constants of Hydrocarbons" (1939–).—This set, restricted to pure hydrocarbons, lists what are considered the most reliable values (to November, 1938) for the melting point, boiling point, specific gravity, and refractive index, together with the original references.

I. Paraffins, olefins, acetylenes, and other aliphatic hydrocarbons.
II. Cycloparaffins, cycloolefins, cycloacetylenes, bi- and dicycloparaffins and cycloolefins, olefin and acetylene substituted cycloparaffins and cycloolefins.
III. Aromatic series and more complex condensed ring systems.
IV. Correlation of physical properties with structure.

Fowle, "Smithsonian Physical Tables" (1933).—A wide variety of mathematical and physical data are included in the nearly 900 tables comprising the eighth edition of this work.

Harrison, "Wavelength Tables" (1939).—More than 100,000 spectrum lines are included in this new, authoritative compilation.

b. Handbooks.[1]—Various smaller works of this type contain the information thought to be of most general interest, such as physical constants for a limited number of organic and inorganic substances, and other similar data in considerable variety. Some, such as those by Perry and the American Society for Metals, contain much more than physical data. Unfortunately, in those more definitely chemical in nature, different authors have selected different items, so that one may need several such works where a considerable range of facts is necessary. Thus one book has an extensive classified list of books, another has much on physics and mathematics, another emphasizes metallurgy, and still another includes outlines of analytical methods. In practically no cases are original references included. Several of the more common works are listed below:

Am. Soc. Metals, "Metals Handbook."
Atack-Hope, "Chemists' Year Book."
Bayley, "A Pocket Book for Chemists."
Cross, "Handbook of Petroleum, Asphalt and Natural Gas."
Hodgman, "Chemical Tables" (from "Handbook of Chemistry and Physics").
Koppel, "Chemiker-Taschenbuch" (3 vols.).
Lange, "Handbook of Chemistry."
Liddell, "The Metallurgists' and Chemists' Handbook."
Olsen, "Chemical Annual" (Not published annually).
Pacific Coast Gas Assoc., "Gas Engineers' Handbook."

[1] For problems involving financial details the following handbooks may be helpful: Alford, "Cost Production Handbook" and "Management's Handbook"; Donald, "Handbook of Business Administration"; Gillette, "Handbook of Construction Cost" and "Handbook of Cost Data for Contractors and Engineers"; Montgomery, "Financial Handbook"; Paton, "Accountant's Handbook."

Perry, "Chemical Engineers' Handbook."
Proctor, "Leather Chemists' Handbook."
Spencer and Meade, "Cane Sugar Handbook."

Perry's work is of special value to chemical engineers for it is intended to supply both the practicing engineer and the student with an authoritative reference work that covers comprehensively the field of chemical engineering as well as important related fields. The 30 sections, compiled by some 60 contributors, cover mathematics, physical and chemical data, materials, processes, economics, reports, and patents. This work duplicates one such as Lange's only to a limited extent.

2. Compilations Combined with Discussions.—In many instances one wants to know merely some physical constant for a given element, compound, or system, and the required information may be found in the tabulations just discussed. In many other instances, more information is required. It may be necessary to know about the occurrence of an element or compound, the methods of preparation and purification, the chemical properties of systems, the uses of materials, the methods of analysis and testing, general relationships, or other facts.

Information of this kind is to be found in a variety of places. It may be in an elementary textbook, if some simple fact about a common element, in a chemical dictionary, or in a monograph. But the best place, in general, to look for such facts is in the works known as treatises. Here one finds facts, together with discussions of them. If the discussion is critical, in the sense that an opinion is given regarding the merit of the material presented, we have the highest type of treatise. Whether critical or not, there is always given an extensive or complete presentation of the material of a given field, based upon some general outline, such as groups of elements or classes of compounds. The more important original references are given.

In preparing these publications it is the general practice to limit the material to some broad field of chemistry, such as organic, inorganic, or biological. Kayser's treatise on spectroscopy is an example of limiting the material to the application of a single instrument in the whole field of chemistry.

Before using a large treatise anyone unfamiliar with it should examine the introductory section to determine any peculiarities

of the set, such as the system of arrangement, abbreviations of periodicals and words, the details of the table of contents, and any limitations regarding the kind of information included.

Time lag is most disconcerting in these large works of reference,[1] since the publication of such sets in up-to-date form is probably the most difficult task in the realm of chemical literature. Examination of the dates of publication of the inorganic treatises described in this section will reveal the present situation for any element that may be selected. When using such sources their dates of publication must be borne in mind.

Occasionally volumes of a treatise (such as certain German sets) seem to have been merely reprinted but bear the date of reprinting rather than that of the original issue. Unless accompanied by some statement to this effect, such practice may be very misleading to the searcher.

Some of the more important general treatises will now be considered. Smaller works may be found by referring to the lists of books at the end of this chapter.

a. Organic Chemistry.—Attention will be given first to the works which deal with the chemistry of the compounds of carbon. No other element in the periodic table has such a number and variety of important compounds. The presentation of the information now known about them has resulted in several extensive treatises.

Beilstein, "Handbuch der organischen Chemie."[2]—The outstanding treatise on general organic chemistry is that originated by F. K. Beilstein, the first edition of two volumes being completed in 1882 after 20 years of work. The third edition, consisting of four main volumes, four supplements and an index, was the last by Beilstein himself. It is to this issue that reference is made so often in the third edition of Richter's "Lexikon." The fourth edition has been issued by the Deutsche Chemische Gesellschaft under the editorship of Friedrich Richter. Exclusive of the naturally occurring compounds of unknown composition (Division IV), 27 volumes were required. These cover the literature only to 1910. Fifteen supplementary volumes bring the literature for the first three divisions up to 1920. Work on a second

[1] MELLON, *J. Chem. Education*, **10**, 284 (1933).

[2] See *J. Chem. Education*, **15**, 303, 310 (1938).

supplement is under way, and Division IV will be completed soon. As someone has said, anyone unfamiliar with this stupendous monument to industrious, intelligent compilation should not consider himself an informed organic chemist.

The general arrangement has always been based on classes of compounds, as hydrocarbons, ketones, and other general types. For the fourth edition the classification was modified so that 4877 sections (Systemnummer) are supposed to meet all requirements. The accompanying outline shows the distribution of the material in the various volumes of the set, together with a general statement of the scheme of classification used.

Indexes, abbreviations of literature sources, other abbreviations, an extensive classified table of contents, and corrections for previous volumes are given in each volume. References to the literature are given in the body of the text. At the top of each page of the supplements is the page number of the main volume in which the same compounds were discussed.

Divisions.—The compounds are first arranged in four main divisions on the basis of whether their structure is known, and, if so, how the carbon atoms are bound together.

DIVISION I.—ACYCLIC COMPOUNDS (NOS. 1–449)
(Stem nuclei[1] with carbon alone bound in chain form)

I. Hydrocarbons and —OH, —C=, and =C(OH)—C= derivatives.
II. Carboxylic acids.
III. Carboxylic acid derivatives.
IV. Sulfonic acids, amines, other N cpds., organometallic cpds.

DIVISION II.—ISOCYCLIC COMPOUNDS (NOS. 450–2359)
(Compounds with carbon-to-carbon rings)

V. Hydrocarbons.
VI. Hydroxy cpds., including alcohols, phenols, phenol alcohols.
VII. Carbonyl cpds., including aldehydes, ketones, quinones.
VIII. Hydroxycarbonyl cpds.
IX. Carboxylic acids.
X. Hydroxycarboxylic acids.
XI. Other acids, including S, Se, Te derivatives.
XII. Monoamines.
XIII. Polyamines.
XIV. Carbonyl amines, amino acids.
XV. Hydroxylamines, hydrazines.
XVI. Other nitrogen cpds., organometallic cpds.

[1] Stem nuclei refer to the ultimate groups obtained by substituting hydrogen for all other elements attached to carbon, without disrupting any rings.

DIVISION III.—HETEROCYCLIC COMPOUNDS (Nos. 2360–4720)
(Compounds with other elements besides carbon in the ring)

XVII. One cyclic oxygen (nuclei, —OH, —C= cpds., S, Se, Te derivs.).
XVIII. One cyclic oxygen (—C=, acidic, nitrogen, organometallic cpds.).
XIX. Two (or more) cyclic oxygens.
XX. One cyclic nitrogen (nuclei).
XXI. One cyclic nitrogen (—OH, —C= cpds.).
XXII. One cyclic nitrogen (other derivs.).
XXIII. Two cyclic nitrogens (nuclei, —OH cpds.).
XXIV. Two cyclic nitrogens (—C= cpds.).
XXV. Two cyclic nitrogens (other cpds.).
XXVI. Three to eight cyclic nitrogens.
XXVII. Compounds with both cyclic oxygen and nitrogen atoms.
. Subject index } Divisions I–III, including first supplement.
:. Formula index }

DIVISION IV.—COMPOUNDS OF UNCERTAIN STRUCTURE (Nos. 4721–4877)
XXX. Caoutchouc, gutta-percha, balata, carotinoids (Lit. to 1935).
XXXI. Monosaccharides, oligosaccharides (Lit. to 1920).
XXXII. Polysaccharides.
XXXIII. Alkaloids.
XXXIV.
XXXV.

Generally an inspection of the structural formula will indicate in which of the three divisions a compound of known structure belongs. In the more complicated and uncertain cases the formula may be broken down into the simpler stem nuclei by substituting hydrogen for all the other elements bound to carbon, without disrupting any ring. According to the principle of latest position, the compound will be found in the last division to which any of its nuclei belong.

Subdivisions.—Only the heterocyclic division (III) has subdivisions. They are arranged in arbitrary sequence according to the kind and number of hetero atoms, such as oxygen and nitrogen, in the ring. Thus compounds with oxygen in the ring come before those with nitrogen, and both of these before compounds containing oxygen and nitrogen in the ring.

Classes.—Divisions I and II and the heterocyclic subdivisions are then arranged in classes on the basis of 28 functioning groups.[1]

[1] In a given Division there may be less or more than 28 numbered classes. In some cases compounds containing all the functioning groups are not known. Then again a separate class number may be assigned each metallic

Class 1 includes only stem-nuclei compounds, such as ethane, benzene, and pyridine. In each of the others the compound contains a group having at least 1 hydrogen atom replaceable by another substituent. The classes, arranged in the order of discussion in each division, follow:

1. Stem nuclei	
2. Hydroxy compounds	—OH
3. Carbonyl compounds	=O or $\left(\begin{smallmatrix}\diagup\text{OH}\\ \diagdown\text{OH}\end{smallmatrix}\right)$
4. Carboxylic acids	=O(OH) or $\left(\begin{smallmatrix}\diagup\text{OH}\\ \text{—OH}\\ \diagdown\text{OH}\end{smallmatrix}\right)$
5. Sulfinic acids	—SO(OH)
6. Sulfonic acids	—SO_2(OH)
7. Seleninic and selenonic acids	—SeO(OH) and —SeO_2(OH)
8. Amines	—NH_2
9. Hydroxylamines	—NHOH
10. Hydrazines	—NH.NH_2
11. Azo compounds	—N:NH
12–22. Other nitrogen compounds	
23–28. Organometallic compounds	

Under each class is included certain general information on nomenclature, properties, and derivatives.

Subclasses.—In arranging compounds in subclasses the sequence is according (1) to decreasing saturation in stem nuclei, as C_nH_{2n+2}, C_nH_{2n}, . . . compounds; (2) to the number of single characteristic functioning groups, as mono-, di-, tri-, . . . compounds; and (3) to the increasing number of different characteristic groups, as carbonyl, hydroxycarbonyl, amino-hydroxycarbonyl, . . . compounds.

Rubrics.—Decreasing saturation is also the basis of arrangement within the subclasses, Rubric 1 being the most highly saturated type. Each rubric may then be expressed in terms of a general formula, as $C_nH_{2n+2}O$ for monohydroxy alcohols.

Series.—In each rubric group the compounds of the same degree of saturation are arranged in the order of increasing number of

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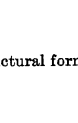
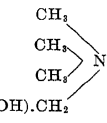
element, which may make more than 28 actual classes. Since those included are numbered consecutively, a given type of compound can not be assigned a class number without consulting the set.

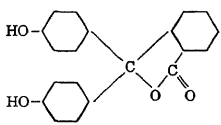
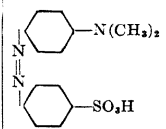
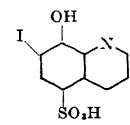
EXAMPLES ILLUSTRATING THE

Common name	Dimethylglyoxime	Choline
I.U.C. name	2,3-Butanedioxime	Trimethyl-2-hydroxy ethyl ammonium hydroxide
Empirical formula	$C_4H_8O_2N_2$	$C_5H_{15}O_2N$
Structural formula		
Division	Acyclic	Acyclic
Subdivision	.....	.....
Class	3. Carbonyl compounds	8. Amines
Subclass	Dicarbonyl compounds	Amino derivative of monohydroxy compounds
Rubric	$C_nH_{2n-2}O_2$	$C_nH_{2n+2}O$
Series	C_4	C_2
Index compound	2,3-Butanedione	Aminoethyl alcohol
Beilstein reference	I-772; I_I-398	IV-277; IV_I-425
System number	95	353

carbon atoms. The series designation, as C_3, shows the number of carbon atoms in the compound. The individual members of the series are the index or parent compounds.

For each index compound the available material is arranged as follows: (1) structure, configuration, historical; (2) occurrence, formation, preparation; (3) properties (color, crystallography, physical constants); (4) chemical properties; (5) physiological action; (6) uses; (7) analytical data (detection, examination, esti-

BEILSTEIN CLASSIFICATION

Phenolphthalein	Methyl orange	Ferron
2,2-Bis (p-hydroxyphenyl) phthalide	p(p-Dimethylamino-phenylazo) benzene-sulfonic acid	7-Iodo-8-hydroxy-quinoline-5-sulfonic acid
$C_{20}H_{14}O_4$	$C_{14}H_{15}O_3N_2S$	$C_9H_6O_4SI$
		
Heterocyclic	Isocyclic	Heterocyclic
.....	.....	1-cyclic N
4. Carboxylic acids	12. Azo compounds	5. Sulfonic acids
Hydroxy-carbonyl cpds. with four oxygens	Azo derivatives of monoamines	Monohydroxysulfonic acids
$C_nH_{2n-26}O_4$	$C_nH_{2n-8}N$	$C_nH_{2n-11}ON$
C_{20}	C_6	C_9
Phthalide	1-Amino-4-azoben-zene	8-Hydroxyquinoline
XVIII-143, XVIII$_I$-373	XVI-331; XVI$_I$-317	XXII-408; XXII$_I$-620
2539	2172	3380

mation); (8) addition compounds and salts; and (9) derivatives.

Derivatives.—The derivatives which each index compound may form require special consideration. There are three types:

a. Functional Derivatives.—These are produced, in effect, by replacing the characteristic hydrogen of the functioning group by an organic or inorganic group (atom). The process involves the reaction of the index compound with some coupling compound, either organic or inorganic, with the elimination of water.

Organic coupling compounds contain a hydroxyl group attached to carbon. Inorganic coupling compounds function through a hydroxyl group, as in hydrogen peroxide and oxygenated acids, or a hydrogen directly attached to a halogen, nitrogen, or certain other elements in the periodic system. Such hydrides couple only with hydroxyl in the index compound.

b. Nonfunctional Derivatives.—These are produced by substituting hydrogen of the stem nucleus by one or more of the nonfunctioning groups, —F, —Cl, —Br, —I, —NO, —NO_2, —N_3.

c. Replacement Derivatives.—These are produced by replacing the oxygen of a functioning group by sulfur, selenium, or tellurium.

Finding a Compound.—Ability to locate facts for a given compound is the test of one's knowledge of the set. Where this brief outline is inadequate, the student should consult more comprehensive sources.[1] Finding some compounds is a real puzzle, but familiarity with the set will yield results worth the effort required to master the scheme.

The chart on pages 118–119 illustrates the general scheme of classification used. Unfortunately, the important process by which one reasons from the structural formula to the index compound can not be summarized briefly in this manner.

Grignard, "Traité de chimie organique."—The first comprehensive treatise in this field in French was started under Grignard's direction. Since his death, R. Locquin and G. Dupont have continued the work. This treatise, planned as indicated below, aims to summarize many aspects of organic chemistry rather than to present the details about myriads of compounds.

I (1935) Analysis, constitution, isomerism, nomenclature.
II (1936) Optical and electrical properties, mechanism of reactions.
III (1935) Aliphatic and cyclic hydrocarbons, derivatives.
IV (1936) Benzene and its derivatives, petroleum.
V (1937) Alcohols, ethers, organometallic compounds.

[1] See (*a*) The introduction to the set in Vol. I; (*b*) PRAGER, STERN, and ILBERG, "System der organischen Verbindungen," a 246-page explanatory volume in which are listed the 4877 classes, common names, and a class index; (*c*) HUNTRESS, "The Use of Beilstein's Handbuch der organischen Chemie," 44 pp.; and (*d*) SOULE, "Library Guide for the Chemist," pp. 127–154 (1938).

VI ( ) Polyhydroxy alcohols, phenols, thiols.
VII ( ) Aldehydes, ketones.
VIII (1938) Quinones and derivatives, cellulose and derivatives.
IX ( ) Acids; derivatives.
X (1939) Di- and poly-aliphatic acids; S and Se derivatives.
XI ( )
XII ( )
XIII ( )
XIV (1939) Nitrogen compounds; As, P and Si compounds.

Meyer and Jacobson, "Lehrbuch der organischen Chemie."—This set, excelled only by that of Beilstein, is the second most important general reference work in this field in German. The arrangement is by types of compounds, as indicated by the contents of each volume.

I_I (1922) General part; aliphatic compounds.
I_{II} (1923) Aliphatic compounds.
II_I (1923) Single ring isocyclic compounds.
II_{II} (1923) Multiple ring isocyclic compounds.
II_{III} (1923) Heterocyclic compounds.
II_{IV} (1924) Natural products of unknown composition.
II_V (1929) Proteins.

The reader should bear in mind that at least part of the years given are the reprinting dates for an earlier edition.

Richter-Anschütz, "Chemie der Kohlenstoffverbindungen."—Less comprehensive yet is the work originated by M. M. Richter and now issued in the twelfth edition by R. Anschütz. English translations have long been popular as reference works. The four volumes are divided as shown (English translation):

I (1934) Aliphatic compounds.
II_I (1939) Alicyclic compounds, natural materials.
II_{II} (1940) Aromatic compounds, free organic radicals.
III ( ) Heterocyclic compounds.

Gilman, "Organic Chemistry" (1938).—This is a new treatise for instruction at the graduate level. It is a collaborative work by some 30 specialists covering in two volumes 22 of the important phases of the subject.

Cohen, "Organic Chemistry."—The three-volume edition of Cohen's work (1928) has been a valuable presentation of information on the reactions, structure, and synthesis of organic compounds.

Houben-Weyl, "Die Methoden der organischen Chemie."—For the investigator in organic chemistry this is one of the most important works of reference. In it may be found methods for performing, and references relating to, nearly every kind of reaction used in this field. A selection of typical topics is indicated for each volume.

I (1925) Analytical methods, general operations.
II (1927) General reactions.
III (1930) Group reactions, halogen compounds, polymerization. . . .
IV (1924) Group reactions, organometallic compounds. . . .

Meyer, "Lehrbuch der organisch-chemischen Methodik."—A shorter presentation of laboratory methods is contained in the three volumes of this set.

I (1938) Analysis and determination of constitution.
II (1933) Detection and estimation of organic compounds.
III_I (1938) Synthesis of open chain and isocyclic compounds.
III_{II} (1939) Synthesis of heterocyclic compounds.

"Organic Syntheses."—Since 1921, American organic chemists have been issuing this work as an annual compilation of satisfactory new laboratory methods for preparing organic compounds. Usually the editorship changes each year.

b. Inorganic Chemistry.—The arrangement of material in inorganic treatises follows more or less closely the order of the family groups in the Mendeléeff form of the periodic table. Unfortunately, the form followed usually is not that embodying the modern conception[1] that a period ends rather than begins with a rare gas. In almost all respects the Bohr form seems preferable (see tables).

Mellor, "Comprehensive Treatise on Inorganic and Theoretical Chemistry."—The arrangement of Mellor's treatise follows somewhat the order of the periodic table. Often general principles or theories are discussed in connection with certain elements. The volumes include the material shown.

I (1922) General principles, H, O.
II (1922) F, Cl, Br, I, Li, Na, K, Rb, Cs.
III (1923) Cu, Ag, Au, Ca, Sr, Ba, Radioactivity.

[1] MIDDLETON and WILLARD, "Semimicro Qualitative Analysis," p. 26 (1939).

IV (1923) Ra family, Be, Mg, Zn, Cd, Hg.
V (1924) B, Al, Ga, In, Tl, Sc, Ce, rare earth metals, C (part I).
VI (1925) C (part II), Si, silicates.
VII (1927) Ti, Zr, Hf, Th, Ge, Sn, Pb, inert gases.
VIII (1928) N, P.
IX (1929) As, Sb, Bi, V, Cb, Ta.
X (1930) S, Se.
XI (1931) Te, Cr, Mo, W.
XII (1932) U, Mn, Ma, Re, Fe (part I).
XIII (1934) Fe (part II).
XIV (1935) Fe (part III), Co.
XV (1936) Ni, Ru, Rh, Pd, Os, Ir.
XVI (1937) Pt, general index.

The order of presentation under each element is history, preparation, properties, and the hydride, oxide, halide, sulfide, sulfate, carbonate, nitrate, and phosphate compounds. Compounds with elements such as arsenic, carbon, and silicon are described under these elements. Potassium chloride will be found under potassium, but potassium peroxysulfate is under sulfur. Intermetallic compounds and complex salts discussed under a given element include only compounds with elements already described.

The subject or name of the compound being considered is printed in bold-faced type so that one's eye readily catches it. The original references are grouped at the end of the various sections. The discussion on a given subject usually divides itself into several phases. Suppose it is the first phase being discussed. Mellor has collected all references for this part under "1" at the end of the section, this numeral being mentioned only once—in connection, usually, with the first author named. The numeral is not repeated for the succeeding authors mentioned, but their names will be found by looking through the list under "1."

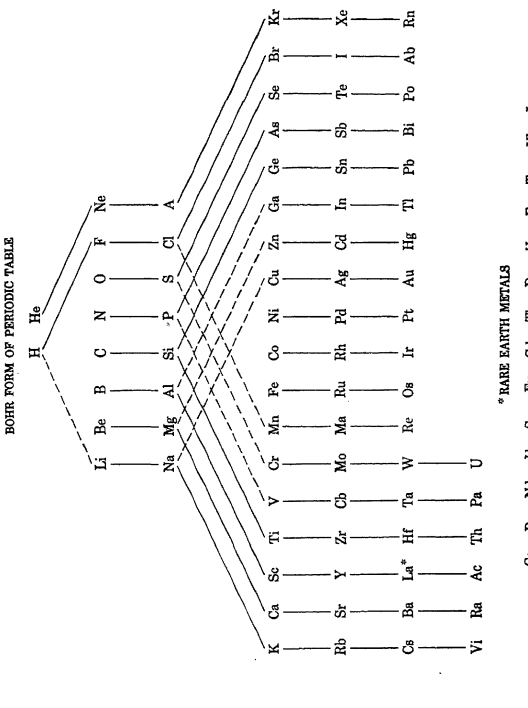
Gmelin, "Handbuch der anorganischen Chemie."—Leopold Gmelin issued the first edition of his "Handbuch der theoretischen Chemie" in 1817. The work has occupied a place so important in the development of inorganic chemistry since that time that the eighth edition is now being issued by the Deutsche Chemische Gesellschaft, under the editorship of R. J. Meyer, with the title of "Handbuch der anorganischen Chemie." It promises to be the most elaborate and exhaustive reference work

MODIFIED MENDELÉEFF PERIODIC TABLE

Period	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
1							$_{1}$H	$_{2}$He
2	$_{3}$Li	$_{4}$Be	$_{5}$B	$_{6}$C	$_{7}$N	$_{8}$O	$_{9}$F	$_{10}$Ne
3	$_{11}$Na	$_{12}$Mg	$_{13}$Al	$_{14}$Si	$_{15}$P	$_{16}$S	$_{17}$Cl	$_{18}$A
	Family							
4	$_{19}$K $_{29}$Cu	$_{20}$Ca $_{30}$Zn	$_{21}$Sc $_{31}$Ga	$_{22}$Ti $_{32}$Ge	$_{23}$V $_{33}$As	$_{24}$Cr $_{34}$Se	$_{25}$Mn $_{35}$Br	$_{26}$Fe $_{27}$Co $_{28}$Ni $_{36}$Kr
5	$_{37}$Rb $_{47}$Ag	$_{38}$Sr $_{48}$Cd	$_{39}$Y $_{49}$In	$_{40}$Zr $_{50}$Sn	$_{41}$Cb $_{51}$Sb	$_{42}$Mo $_{52}$Te	$_{43}$Ma $_{53}$I	$_{44}$Ru $_{45}$Rh $_{46}$Pd $_{54}$Xe
6	$_{55}$Cs $_{79}$Au	$_{56}$Ba $_{80}$Hg	$_{57}$La* $_{81}$Tl	$_{72}$Hf $_{82}$Pb	$_{73}$Ta $_{83}$Bi	$_{74}$W $_{84}$Po	$_{75}$Re $_{85}$(Ab)	$_{76}$Os $_{77}$Ir $_{78}$Pt $_{86}$Rn
7	$_{87}$(Vi)	$_{88}$Ra	$_{89}$Ac	$_{90}$Th	$_{91}$Pa	$_{92}$U		

*RARE EARTH METALS

$_{58}$Ce	$_{59}$Pr	$_{60}$Nd	$_{61}$Il	$_{62}$Sm	$_{63}$Eu	$_{64}$Gd
$_{65}$Tb	$_{66}$Dy	$_{67}$Ho	$_{68}$Er	$_{69}$Tm	$_{70}$Yb	$_{71}$Lu


BOHR FORM OF PERIODIC TABLE
1
2
3
4
5
6
7
H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl A
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Cb Mo Ma Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La* Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po Ab Rn
Vi Ra Ac Th Pa U
*RARE EARTH METALS
Ce Pr Nd Il Sm Eu Gd Tb Dy Ho Er Tm Yb Lu

available covering inorganic chemistry. It is essentially a discussion covering the history, occurrence, properties, scientific methods of preparation, and commercial processes of manufacture, with particular emphasis placed upon the physico-chemical and technical material.

For compiling the information the elements are arranged in a list resembling that in Hoffmann's "Lexikon," except that it begins with the rare gases and ends with the heavy metals. The work is being issued in the form of a separate part for each of the 70 entries in the list, so that the part published as "System-nummer 1" deals with the rare gases. Binding of the parts in the projected volumes is not always feasible on account of their size.

Volume	Number system	Contents and date
I	1, 2	Rare gases ('26), H ('27)
II	3, 4	O ( ), N ('34–)*
III	5, 6, 7, 8	F ('26), Cl ('27), Br ('31), I ('33)
IV	9, 10, 11, 12	S ( ), Se ( ), Te ( ), Po ( )
V	13, 14, 15	B ('26), C ( ), Si ( )
VI	16, 17, 18, 19	P ( ), As ( ), Sb ( ), Bi ('27)
VII	20, 21	Li ('27), Na ('28)
VIII	22, 23, 24, 25	K ('36–), NH_4 ('36), Rb ('37), Cs ('38)
IX	26, 27, 28, 29, 30, 31	Be ('30), Mg ('37–), Ca ( ), Sr ('31), Ba ('32), Ra ('28)
X	32, 33	Zn ('24), Cd ('25)
XI	34	Hg ( )
XII	35, 36, 37, 38	Al ('34–), Ga ('36), In ('36), Tl ( )
XIII	39, 40	Rare earths ('38–), Ac ( )
XIV	41, 42, 43, 44	Ti ( ), Zr ( ), Hf ( ), Th ( )
XV	45, 46, 47	Ge ('31), Zn ( ), Pb ( )
XVI	48, 49, 50, 51	V ( ), Cb ( ), Ta ( ), Pa ( )
XVII	52, 53, 54, 55	Cr ( ), Mo ('35), W ('33), U ('36)
XVIII	56, 57, 58	Mn ( ), Ni ( ), Co ('31–)
XIX	59	Fe ('29–)
XX	60, 61, 62	Cu ( ), Ag ( ), Au ( )
XXI	63, 64, 65, 66, 67	Ru ('38), Rh ('38), Pd ( ), Os ('39), Ir ('39)
XXII	68, 69, 70	Pt ('38–), Ma ( ), Re ( )

In each case the element itself is first discussed. This is followed by a consideration of its binary compounds, with all the

* The dash indicates that the volume appeared in parts in different years.

elements above it in the list, in the order shown. More complex compounds follow in the same manner. Supplements for certain metals cover their alloys and patents.

References to the literature are included in parentheses in the body of the discussion, and they are supposedly complete to within 6 months of the date of publication (see back of title page).

The English translation by Watts of an earlier edition (1848–1872) in 19 volumes is an important source of references to the early literature on chemistry.

Abegg, "Handbuch der anorganischen Chemie."—The set started by R. Abegg, and continued by F. Auerbach and I. Koppel, is much more selective and critical than the Mellor or Gmelin sets. Each bound volume is introduced by a summary of the chemistry of the elements included in the group. The separate parts, prepared by specialists, have the references collected at the end and the appended date shows how nearly the material is up-to-date. Some volumes may carry the misleading reprinting date on the title page. Although started in 1905, the set is still incomplete. The arrangement follows the periodic system, as indicated below, with the original date of publication.

I	
II_I (1908)	H, Li, Na, K, Rb, Cs, Cu, Ag, Au.
II_{II} (1905)	Be, Mg, Ca, Sr, Ba, Ra, Zn, Cd, Hg.
III_I (1906)	B, Al, Sc, Yt, rare earths, Ga, In, Tl.
III_{II} (1909)	C, Si, Ti, Zr, (Hf), Th, Ge, Sn, Pb.
III_{III} (1907)	N, NH_4, P, As, Sb, Bi, V, Cb, Ta, (Pa).
$IV_{I,1}$ (1927)	O, S, Se, Te, (Po).
$IV_{I,2}$ (1921)	Cr, Mo, W, U.
IV_{II} (1913)	F, Cl, Br, I, Mn, (Ma), (Re).
$IV_{III,1}$ (1928)	He, Ne, Ar, Kr, Xe, Rn.
$IV_{III,2A}$ ('31–8)	Fe (element, alloys, binary compounds).
('30–5)	Fe (complexes, colloids, catalysis).
(1934)	Co.
$IV_{III,4}$ ('37–9)	Ni.
$IV_{III,I}$	

Friend, "Textbook of Inorganic Chemistry."—This work, with the various parts written by specialists under the editorship of J. N. Friend, was designed to cover the field as shown in the

table. In the announcement of the set it was stated that the "aim is to give in detail the most important parts of each subject treated, and to supplement lack of detail in other parts by copious references (at bottom of page) to the best literature." New editions of some volumes are appearing to replace those bearing the dates shown.

I (1914). General principles; He, Ne, A, Kr, Xe, Rn.
II (1924) H, Li, Na, K, Rb, Cs, NH_4, Cu, Ag, Au.
III_I (1925) Ca, Sr, Ba, Ra.
III_{II} (1926) Be, Mg, Zn, Cd, Hg.
IV (1921) B, Al, Ga, In, Tl, Sc, rare earths, Ac.
V (1921) C, Si, Ti, Zr, Th, Ge, Sn, Pb
VI_I (1928) N.
VI_{II} (1934) P.
VI_{III} (1929) V, Cb, Ta.
VI_{IV} (1938) As.
VI_V (1936) Sb, Bi.
VII_I (1924) O.
VII_{II} (1931) S, Se, Te.
VII_{III} (1926) Cr, Mo, W, U.
$VIII_I$* ( ) F, Cl.
$VIII_{II}$ ( ) Br, I.
$VIII_{III}$ ( ) Mn, Ma, Re.
IX_I (1922) Co, Ni, Ru, Rh, Pd, Os, Ir, Pt.
IX_{II} (1925) Fe.
X (1928) Metal ammines.
XI_I (1928) Organometallic compounds—Groups I–IV.
XI_{II} (1930) Organometallic compounds—As.
XI_{III} (1936) Organometallic compounds—P, Sb, Bi.
XI_{IV} (1937) Organometallic compounds—Se, Te, Cr, Pt

Pascal, "Traité de chimie minerale."—In general nature the set edited by Pascal resembles that of Abegg. It is the newest and most promptly completed inorganic set. There are good summaries of selected topics such as complex compounds and the rare earths. The references, collected at the end of the sections, are printed in run-in form in groups of ten.

I (1931) Introduction, air, water, H, O, F, Cl, Br, I.
II (1932) S, Se, Te, sulfuric acid industry.
III (1932) N, P, As, nitrogen industry.
IV (1933) Sb, Bi, V, Cb, Ta, B.
V (1932) C, Si, Ti, Ge, Zr, Hf, NH_4.

* VIII was originally one volume (1915).

VI (1934) Li, Na, K, Rb, Cs, alkali industry, Ca, Ba, Sr, Ra.
VII (1932) Be, Mg, Zn, Cd, Al, Ga, In, cement, glass.
VIII (1933) Rare earths, Cu, Ag, Au, Hg.
IX (1933) Sn, Pb, Tl, Mn, Re, Fe.
X (1933) Ni, Co, Cr, complexes.
XI (1932) Mo, W, U, Th, Ru, Rh, Pd, Os, Ir, Pt.
XII (1934) Rare gases, alloys, radioactive elements.

Doelter and Leitmeier, "Handbuch der Mineralchemie."—This set differs from the previous sets on inorganic chemistry in stressing the phases of the subject of more direct interest to the mineralogist and geologist.

I (1912) Introduction, C, carbonates, silicates.
II_I (1914) Silicates.
II_{II} (1919) Silicates of tervalent metals.
II_{III} (1921) Silicates of tervalent metals.
III_I (1918) Ti, Zr, Sn, Th, Cb, Ta, N, P, As, Sb, Bi, V, H.
III_{II} (1926) Li, Na, K, Rb, Cs, Cu, Ag, Au, Be, Mg, Ca, Sr, Ba, Zn, Cd, Hg, Ra, B, Al, Ga, In, Tl, Fe, Mn, Co, Ni, rare earth and platinum metals.
IV_I (1926) Sulfur compounds.
IV_{II} (1929) Sulfates, Cr, Mo, W, U, halide salts, salt deposits.
(1931) Halides, fluorides, rare gases, organic substances, index.

Stähler, "Handbuch der Arbeitsmethoden in der anorganischen Chemie."—The compilation of Stähler (assisted by Tiede and Richter) includes material dealing with laboratory operations in inorganic chemistry.

I (1913) Inorganic chemical laboratory, mechanical operations.
II_I (1919) General physical and chemical operations.
II_{II} (1925) Special physical and chemical operations.
III_I (1913) Physicochemical determinations.
III_{II} (1914) Physicochemical determinations.
IV_I (1916) Preparation of gases, colloids, metals, and alloys.
(1926) Selected preparations, general index.

"Inorganic Syntheses."—This publication, started in 1938 to include checked and tested methods for the preparation of important inorganic chemicals, is comparable to "Organic Syntheses." The editorship rotates.

Jacobson, "Encyclopedia of Chemical Reactions."—The plan of this treatise[1] comprises the alphabetical listing under each

[1] *J. Chem. Education*, **10**, 614 (1933). (Book awaiting publication.)

element of all active inorganic substances, together with a limited number of organic compounds, and in a marginal space to the left all substances known to react with the former. The following entry illustrates the plan:

Lithium

No. 46 Lithium dissolves in hydrochloric acid with evolution of gas.
HCl

$$2Li + 2HCl \rightarrow 2LiCl + H_2$$

Bunsen, *Ann.*, **94**, 110 (1855)

c. Analytical Chemistry.—Only in comparatively recent times has there been available for analytical chemistry a reference set at all comparable to the comprehensive works mentioned above. The general practice has been to limit the publications to more or less restricted phases of this field of chemistry. The following works are important for general reference purposes:

Rüdisüle, "Nachweis, Bestimmung und Trennung der chemischen Elemente."—This set contains a general discussion of the qualitative reactions and the approved methods, including technical and special methods, for the quantitative determination and separation of each of the elements. The material, issued or projected, is arranged as follows:

I (1913) As, Sb, Sn, Te, Se.
II (1913) Au, Pt, V, W, Ge, Mo, Ag, Hg.
III (1914) Cu, Cd, Bi, Pb.
IV (1916) Pd, Rh, Ir, Ru, Os, Be, Fe, Ti, Si.
V (1918) Al, Ni, Co, Mn, Zn, Cr, U.
VI_I (1923) B, K, Na, NH_4, Cs, Rb, Mg, Ba, Sr, Ca.
VI_{II} (1923) Tl, Th, Zr, Ce, Pr, Nd, La, Sa, Y, Er, Ga, Yb, Sc, In, Cb, Ta, Ra.
VII_I (1929) S.
VII_{II} ( ) C.
VII_{III} ( ) N.
VII_{IV} ( ) P.
VIII ( ) F, Cl, Br, I, O, H, He, Ne, A, K, Xe, Rn.
IX ( ) Analysis of Natural and Artificial Products.
*I (1936) Supplement, Vols. I–IV.

Allen, "Commercial Organic Analysis."—The fifth edition of this set is a treatise on organic chemicals and their products as used in commerce, arts, manufacturing and medicine, giving

physical and chemical properties, methods of analysis, proximate analytical examination, and practical methods for the detection and estimation of impurities, adulterations and products of decomposition. The following selected topics indicate the range covered.

I (1923) Liquors, sugars, paper, aliphatic acids.
II (1924) Oils, fats, waxes, soaps, glycerol.
III (1925) Hydrocarbons, aromatic derivatives.
IV (1925) Essential oils, resins, rubber, gutta-percha.
V (1927) Inks, amines, natural coloring materials, aromatic derivatives.
VI (1928) Colorimetry, dyes, synthetic dyestuffs.
VII (1929) Alkaloids, coffee, tea, chocolate, tobacco.
VIII (1930) Glucosides, enzymes, acids, proteins.
IX (1932) Plant proteins, milk, meat.
X (1933) Hemoglobin, structural proteins, vitamins, index.

Berl-Lunge, "Chemisch-technische Untersuchungsmethoden."—The eighth edition of Lunge's set, edited by E. Berl, is the most comprehensive compilation (over 7000 pages) of commercial methods of testing, analyzing, and evaluating industrial materials. The discussion, dealing primarily with analytical and control methods of German chemical industry, is indicated by the selected topics listed.

I (1931) General qualitative and quantitative methods, microanalysis.
II_I (1932) Fuels, water, air, acids, alkalies, compressed gases.
II_{II} (1932) Electrodepositions, assaying, methods for individual metals.
III (1932) Ceramic products, fertilizers, explosives.
IV (1933) Gas, coal tar, fats and waxes, petroleum.
V (1934) Miscellaneous organic products.
(1939) Supplements (in three parts).

Klein, "Handbuch der Pflanzenanalyse."—This work is an example of a treatise which deals with the analytical measurements of value in a special field.

I (1931) General methods of plant analysis.
II (1932) Inorganic constituents, organic constituents (I).
III (1932) Organic constituents (II).
IV (1933) Organic constituents (III), special methods.

Scott-Furman, "Standard Methods of Chemical Analysis" (1938).—The fifth edition of Scott's standard work has been prepared by some 50 specialists under the editorship of N. H. Furman. The two large volumes are divided as shown.

I Selected methods for each element, brief scheme for qualitative analysis, numerical tables, reagents, and apparatus.

II Sampling, alloys, bituminous substances, cement, coal, explosives, oils, fats, waxes, petroleum, paints, paper, poisons, rubber, slag, soap, water, hydrogen ion, potentiometry, gas analysis, microscopy, microanalysis, metallography, and spectroscopy.

Margosches-Böttger, "Die chemische Analyse."—This set of over 40 volumes is really a series of monographs on special phases of quantitative chemical analysis. The following titles, with the number, year, author, and title, are representative:

3 (1930) Herz, "Physical Chemistry as a Foundation for Analytical Chemistry."
26 (1934) Jander and Pfundt, "Visual Conductivity Titrations."
33 (1935) Brennecke, Fajans, Furman, and Lang, "Newer Methods of Volumetric Analysis."
37 (1937) Prodinger, "Organic Precipitating Agents in Quantitative Analysis."
39 (1939) Bayer, "Gas Analysis."

The following less comprehensive works are very useful:

Böttger, "Physical Methods of Analytical Chemistry," 3 v.
Chamot and Mason, "Handbook of Chemical Microscopy," 2 v.
Gardner, "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors."
Hillebrand and Lundell, "Applied Inorganic Analysis."
Kayser, "Handbuch der Spektroscopie," 8 v.
Lunge-Keane, "Technical Methods of Analysis," 3 + v.
Lewkowitsch, "Oils, Fats and Waxes," 3 v.
Mulliken, "Identification of Pure Organic Compounds," 4 v.
Peters and Van Slyke, "Quantitative Clinical Chemistry," 2 v.
Post, "Chemisch-Technische Analyse," 8 v.
Rosin, "Reagent Chemicals and Standards."[1]
Snell and Snell, "Colorimetric Methods of Analysis," 2 v.
Thierfelder, "Handbuch der physiologisch- und pathologisch chemischen Analyse.
Treadwell-Hall, "Analytical Chemistry," 2 v.
Villavecchia, "Treatise on Applied Analytical Chemistry," 2 v.
Yoe, "Photometric Chemical Analysis," 2 v.
———, "Table of Reagents for Inorganic Analysis."
Official Methods:
Assoc. Official Agr. Chemists, "Methods of Analysis."
Am. Public Health Assoc., "Standard Methods of Water Analysis."
Am. Soc. Testing Materials, "A.S.T.M. Standards."[1]

[1] Specifications are given for many commodities.

Intern. Soc. Leather Trades Chemists, "Official Methods of Analysis."
U. S. Pharm. Convention, "Pharmacopoeia of the United States."

In addition to the works mentioned above, there are many briefer works; in general, however, they are devoted to special fields. For such sources the lists of books mentioned at the end of this chapter should be consulted.

d. Physical Chemistry.—For the present purpose physical or theoretical chemistry may be considered as that branch of the science which deals with the cause and nature of chemical transformations and with the interpretation of specific properties. Since organic and inorganic chemistry include all the chemical elements, and therefore all chemical materials, one would expect to find much discussion belonging to this field in the treatises already considered. Consequently, the tendency has been toward single-volume textbooks and monographs on limited portions of the field, rather than toward treatises. However, several works of the latter type are available (see also Appendix for works on physics).

Ostwald, "Handbuch der allgemeinen Chemie."—The set initiated by Ostwald and continued by Drucker and Walden may be put in this group. It has not grown into an extensive set.

I (1919) Chemical literature and the organization of science.
II (1918) The rare gases.
III (1919) The properties of gases.
IV (1924) The conductivity of solutions.
V (1928) Mechanical properties of liquids.
VI (1928) Chemical valence and bonding.
VII (1928) Thermochemistry.
$VIII_I$ (1930) Electromotive force.
$VIII_{II}$ (1931) Electrolysis and polarization.
IX (1937) Hydroxides and oxide hydrates.

Jellinek, "Lehrbuch der physikalischen Chemie."—This work is the most comprehensive of the German "textbooks" in the field.

I (1928) General principles, liquid state.
II (1928) Solid state, dilute solutions.
III (1930) Statics, chemical reactions in dilute solutions.
IV (1931) Reactions, chemical kinetics.
V (1933) Concentrated solutions, the phase rule.

Bredig, "Handbuch der angewandten physikalischen Chemie."—The set issued under the editorship of Bredig is more a collection of monographs than a general treatise. Its nature is indicated below.

I (1923) Electrochemistry of aqueous solutions (3d ed.).
II (1905) Physical-chemical mineralogy.
III (1925) Mechanical science for chemists (3d ed.).
IV (1906) Vaporization, condensation, fractional distillation.
V (1927) Spectroscopy and colorimetry (2d ed.).
VI (1926) The phase rule and its use (2d ed.).
VII (1907) Solubility and solubility influences.
VIII (1907) General chemistry of colloids.
IX (1908) Photochemistry and photography.
X (1923) Explosives (2d ed.).
XI (1909) Electrochemistry of molten salts.
XII (1914) Metallography.
XIII (1924) Electrochemistry of non-aqueous solutions.
XIV (1926) The use of X-rays in chemistry and industry.
XV (1931) Electrochemistry of gases.

In the field of physical chemistry there has been some tendency to issue treatises in special fields. The following sets dealing with colloid chemistry are typical:

Alexander, "Colloid Chemistry," 4 v.
Freundlich, "Colloid Investigation Monographs," 10 v.
Weiser, "Inorganic Colloid Chemistry," 3 v.

Many single-volume works have been published dealing with general physical chemistry, or with specialized topics in the field. Such books are usually either textbooks or monographs. Representative titles are given under these headings later in this chapter. For others, consult the lists of books suggested.

e. Industrial Chemistry.—In the general field of industrial or applied chemistry (chemical engineering) there is nothing comprehensive comparable to Beilstein's work in organic chemistry. It is very difficult, if not impossible, to have a compilation of general nature that is reliable. Changes in practice are so frequent and advances in technique so steady that new editions could hardly be arranged with sufficient rapidity to keep up with the pace. The works listed here will be found of some value.

Berl, "Chemische Ingenieur-Technik."—This work, produced with the assistance of some 25 collaborators, is a presentation from a practical viewpoint of German engineering as it applies to chemical industry. The topics listed show the nature of the material.

I (1935) Mathematics, thermodynamics, catalysis, combustion, electrotechnics, materials of construction, regulators.
II (1935) Plants, power, water, refrigeration, handling gases, liquids and solids, drying, furnaces.
III (1935) The unit operations of chemical engineering.

Eucken and Jakob, "Der Chemie-Ingenieur."—Various contributors have presented in this work another collection of general information relating to chemical engineering in Germany. A general index covers parts I and II.

I_I (1933) Hydraulic movement of material, insulation, heat exchange.
I_{II} (1933) Mechanical separation of material.
I_{III} (1933) Thermal separation of material.
I_{IV} (1934) Electrical separation and collection of material.
II_I (1932) Control and regulation equipment.
II_{II} (1933) Works measurement of quantity.
II_{III} (1933) Works measurement of particle size.
II_{IV} (1933) Physicochemical analysis in the plant.
III_I (1937) Physicochemical and economic viewpoints of chemical operations.
III_{II} (1938) Apparatus assembly of chemical operations.
III_{III} ( ) Chemical operations at normal pressure.
III_{IV} (1939) High-pressure operations.

Dammer, "Chemische Technologie der Neuzeit."—This is a new edition, by Peters and Groszmann, of Dammer's "Handbuch der chemischen Technologie." It deals with a wide variety of chemical products, a few of which are indicated.

I (1925) Water, wood, coal, oil, gas.
II_I (1932) Metals and alloys (general).
II_{II} (1933) Iron and steel, many other metals.
III (1927) Metalloids.
IV (1933) Organic products.
V (1932) Organic products.

There are many specialized treatises in this field which deal with particular industries. The following list contains representative titles of such sets:

Clark and Crossley, "Manufacture of Pulp and Paper," 5 v.
Curwen, "Chemistry in Commerce," 4 v.
Dunstan, Nash, Brooks, and Tizard, "The Science of Petroleum," 4 v.
Engelhardt, "Handbuch der technischen Elektrochemie," 4 v. in 7 pts.
Engler, "Handbuch der chemischen Technologie," 12 v.
Gehlhoff and Quasebart, "Das Glas," 10 v.
Hale, "Modern Chemistry, Pure and Applied," 6 v.
Heller, "Handbuch der Chemie und Technologie der Öle und Fette," 4 v.
Kieser, "Handbuch der chemisch-technischen Apparate," 4 v.
Liddell, "Handbook of Chemical Engineering," 2 v.
Lunge-Cumming, "The Manufacture of Acids and Alkalies," 6 v.
Martin, "Industrial and Manufacturing Chemistry," 3 v.
Martin, "The Modern Soap and Detergent Industry," 3 v.
Rogers, "Industrial Chemistry," 2 v.
Roth, "Chemie und Technik der Gegenwart," 8 v.
Schönenfeld, "Chemie und Technologie der Fette und Fettprodukte," 5 v.
Tansz, "Das Erdöl," 4 v.

The general practice in preparing works dealing with chemical technology is to limit them to some special field. Many of these, relating to almost every phase of applied chemistry, have been published. (See works containing lists of books, mentioned at the end of this chapter.)

f. Biological Chemistry.—Several excellent treatises deal with the general subject of biological or physiological chemistry (biochemistry). Some of the most important of these are listed below.

Abderhalden, "Biochemisches Handlexikon."—This set, together with Oppenheimer's, is the great reference source for the biochemist. Abderhalden set out to discuss all compounds which occur in nature, including their physical, chemical, and physiological properties. Certain other organic compounds, chiefly of interest to the biochemist, are considered. The following volumes have appeared (a new edition is under way):

I_I (1911) Hydrocarbons, alcohols, phenols. . . .
I_{II} (1911) Aromatic alcohols, acids. . . .
II (1911) Cellulose, dextrin, glucosides. . . .
III (1911) Fats, waxes. . . .
IV (1911) Proteins, amino acids, polypeptides. . . .
V (1911) Alkaloids, antigens, ferments. . . .
VI (1911) Coloring matters of the animal and plant world.
VII (1912) Tannins, bitter principles. . . .

Supplementary Volumes:

VIII (1914) Glucosides, glycogen. . . .
IX (1915) Proteins, animal coloring matters. . . .
X (1923) Purine bodies, pyrimidines. . . .
XI (1924) Amino acids, urea and derivatives. . . .
XII (1930) Urea, creatinine, polypeptides.
XIII (1931) Pectins, cellulose, carbohydrates.
XIV (1933) Proteins, coloring materials, nucleic acids.

Oppenheimer, "Handbuch der Biochemie des Menschen und der Tiere."—Written from a somewhat different viewpoint than Abderhalden's set, this one is not quite so comprehensive.

I (1924) The constituents of animal substances.
II (1925) Biochemistry of the cell.
III (1925) Specific combination and antibodies.
IV (1925) Tissues, organs, and secretions.
V (1925) Digestion, absorption, excretion.
VI (1926) Gas exchange, nutrition, total metabolism.
VII (1927) Total metabolism under special conditions.
VIII (1925) Special metabolic studies.
IX (1927) Regulation of functions.
*I–III ('33–6) Supplements.

Euler, "Chemie der Enzyme."—This well-known treatise is more specialized than the preceding two.

I (1925) General chemistry of enzymes.
II_I (1928) Hydrolytic enzymes of esters, carbohydrates, and glucosides.
II_{II} (1927) Hydrolytic enzymes of nucleic acids, amides, peptides, and proteins.
II_{III} (1934) The catalases and the enzymes of oxidation and reduction.
II_{IV} ( ) The Fermentation Enzymes.
III ( ) Enzymatic Processes in Organisms.

Bömer, Juckenack, and Tillmans, "Handbuch der Lebensmittelchemie."—This work is on the borderline between biochemistry and agricultural or food chemistry.

I (1933) General constituents of living matter.
II_I (1933) Physical methods.
II_{II} (1935) Chemical and biological methods.
III (1936) Animal foods.
IV (1939) Fats and oils.
V (1938) Grains, sugar, honey, fruits, vegetables.
VI (1934) Alkaloidal condiments, spices, salt.
VII (1938) Alcoholic beverages.
$VIII_I$ (1939) Technology of water.

VIII$_{II}$ (1939) Investigation and evaluation of water, air.
IX ( ) Body needs, vinegar, patent medicines.

Abderhalden, "Handbuch der Biologischen Arbeitsmethoden."—Experimental methods of interest to the biochemist are treated very comprehensively in this great work, the most extensive treatise of use to biochemists. The present edition (2d) was projected to include the following "Abteilungen":

I Chemical methods.
II Physical methods.
III Physicochemical methods.
IV Applied chemical and physical methods.
V Methods for the study of the function of single organs of the animal organism.
VI Methods of experimental psychology.
VII Methods of comparative morphological research.
VIII Methods of experimental morphological research.
IX Methods of investigating the performance of animal organisms.
X Methods of geology, mineralogy, paleobiology, and geography.
XI Methods of investigating the performance of plant organisms.
XII Methods of investigating the performance of unicellular forms of life.
XIII Methods of research for experimental therapy and immunity.

Each Abteilung (division) contains several Teile (parts), and most Teile contain several Lieferungen (sections). Some 200 Lieferungen were projected for the set, each to be prepared by a specialist. They have not been issued in order. The first book appeared in 1925, and by the end of 1939 the set numbered 100 volumes. (There are no volume numbers, however.)

Heffter, "Handbuch der experimentellen Pharmakologie."—The main work, consisting of three volumes in seven parts, was published between 1920 and 1935. Seven supplements appeared in 1935–1938.

Other biochemical sets include König, "Chemie der menschlichen Nahrungs und Genussmittel" (7 v.), Oppenheimer, "Die Fermente und ihre Wirkungen" (3 v.), and Beythien, Hartwich, and Klimmer, "Handbuch der Nahrungsmitteluntersuchung" (4 v.). See treatises under Analytical Chemistry.

g. Agricultural Chemistry.—Agricultural chemistry is largely applied general biochemistry, which in turn rests upon the general principles of inorganic, organic, analytical, and physical chemistry. Therefore, a number of the treatises already described will

be of value here, especially those dealing with biochemistry. In addition, a few deal more specifically with agricultural materials.

Blanck, "Handbuch der Bodenlehre."—This is a general treatise on soils and their care.

I (1929) Scientific basis of the study of soil formation.
II (1929) Weathering and its climatological basis.
III (1930) Study of the distribution of soils on the earth.
IV (1930) Soil formation and weathering of the fossil covering.
V (1930) The soil as the top layer of the earth's surface.
VI (1930) The physical condition of soils.
VII (1931) The soil in its chemical and biological conditions.
VIII (1931) Soil culture and the determination of its fertility.
IX (1931) Methods of cultivating soils.
X (1932) The technical efficiency of the soil, its evaluation and cartographic representation.

Honcamp, "Handbuch der Pflanzenernährung und Düngerlehre." The two large volumes include much material.

I (1931) Plant nutrition.
II (1931) Fertilizers and manures.

Winton and Winton, "Structure and Composition of Foods."—This treatise is for the chemist, the microscopist, and the food worker.

I (1932) Cereals, starch, oil seeds, nuts, oils, forage plants.
II (1935) Vegetables and fruits.
III (1937) Milk, butter, cheese, eggs, meat, fats, fish. . . .
IV (1939) Sugar, honey, tea, coffee, cocoa, spices, extracts. . . .

Also see treatises under Analytical Chemistry and Biochemistry.

h. Pharmaceutical Chemistry.—As with biochemistry and agricultural chemistry, pharmaceutical chemistry comes ultimately to include the chemistry of certain inorganic and organic materials. In this field these materials are the ones that possess remedial or curative physiological properties. The basic chemistry of such substances is covered in treatises already considered. The following treatises are representative of those devoted to the pharmaceutical and pharmacological properties of materials:

Houben, "Fortschritte der Heilstoffchemie," 3 v. in 4 pts. (1930–1939).
Lebeau and Courtois, "Traité de pharmacie chimique," 3 v. (1938).

Thoms, "Handbuch der praktischen und wissenschaftlichen Pharmacie," 6 v. in 12 pts. (1924–1929).

Also see treatises under Analytical Chemistry and Biochemistry.

3. Dictionaries and Encyclopedias.—A third class of general works of reference includes the dictionaries and encyclopedias. These publications are grouped together since the words dictionary and encyclopedia have been used more or less synonymously in connection with chemical publications.

It is the opinion of the author, however, that we should conform to the usage indicated in the current dictionaries of the English language. Here we find a dictionary defined as a work containing the words belonging to some province of knowledge. It deals primarily with words, and is concerned with the word itself. Considered from this standpoint, the true chemical dictionary is one which includes a list of chemical terms with their definitions and usage, rather than one dealing with subjects arranged in alphabetical order.

I think it was P. J. Macquer who apologized for the alphabetic form of the subject matter of his "Dictionnaire de chymie" (1766), by stating that chemistry was little more than a collection of facts scarcely entitled to the name of science, or capable either of synthetic or analytic explanation; and hence he concluded that the dictionary form was the best mode of arranging the facts. The dictionary thus belongs to a primitive stage in the development of a science in that it is but a collection of facts to be employed in building up the science.—MELLOR.

An encyclopedia, on the other hand, "is a comprehensive summary of knowledge or of a branch of knowledge; a work in which the various branches of science are discussed separately." It deals primarily with subjects and is concerned with the thing the word represents. Encyclopedias of chemistry, then, are composed of separate discussions or presentations of topics, in the form of a comprehensive summary of the whole field of chemistry, or a large, representative portion. The usual arrangement is alphabetical by subjects. The general scheme is to give for each topic or subject considered a summary, presenting the information that is considered to be of the most general value. The articles are historical, descriptive, explanatory, and statistical. References may or may not be given to sources where more extensive information is to be found.

With this conception in mind for the distinction between dictionaries and encyclopedias, an attempt has been made to separate the publications belonging to this division into two lists, as shown below. Some mistakes may have been made, since all the works mentioned were not available for examination.

DICTIONARIES

BAILEY and BAILEY, "An Etymological Dictionary of Chemistry and Mineralogy," (1929).
BEADNELL, "Dictionary of Scientific Terms," (1939).
BENNETT, "Standard Chemical and Technical Dictionary," (1939).
BLÜCHER, "Auskunstsbuch für die chemische Industrie," 2 v. (1926).
BROWN and RUNNER, "Engineering Terminology," (1939).
Chemical Age, "Chemical Dictionary," (1925–).
COUCH, "A Dictionary of Chemical Terms," (1920).
DORLAND and MILLER, "The American Illustrated Medical Dictionary," (1929).
GARDNER, "Chemical Synonyms and Trade Names," (1937).
HACKH and GRANT, "Chemical Dictionary," (1937).
HENDERSON and HENDERSON, "A Dictionary of Scientific Terms," (1939).
KOCH and KIENZLE, "Handwörterbuch der gesamten Technik und ihrer Wissenschaften," (1935).
MAERZ and PAUL, "A Dictionary of Color," (1930).
STEDMAN, "A Practical Medical Dictionary," (1937).
WORDEN and WORDEN,[1] "Technical Dictionary of Chemistry," (1940–)

ENCYCLOPEDIAS

BERLINER and SCHEEL, "Physikalisches Handwörterbuch," (1932).
DUVAL, "Dictionnaire de chimie théorique et industrielle," (1939–).
DUVAL, DUVAL, and DOLIQUE, "Dictionnaire de la chimique et de ses applicationes," (1935).
FREMY, "Encyclopédie chimique," 93 v. (1882–1905).
GIUA and GIUA-LOLLINI, "Dizionario di chimica generale e industriale technologica e industriale," 13 v. in 18 pts. (1932–).
GUARESCHI and GARELLI, "Nuova enciclopedia di chimica scientifica," (1906–1927).

[1] This new work, the first of its kind to be prepared in America, is more or less a compromise between a simple dictionary and an encyclopedia. It consists of an alphabetical listing of the trade, patented, trade-mark and trite names of inorganic and organic substances, including drugs and minerals, used in the technological arts, medicine, and pharmacy. Each of the more than 400,000 headings contains the available information for the following items: name (synonyms), formula, kind of material and source, boiling and melting points, physical characteristics, solubility, and applications.

KINGZETT, "Chemical Encyclopedia," (1932).
LADENBURG, "Handwörterbuch der Chemie," 14 v. (1883–1896).
LIEBIG, POGGENDORFF, and WÖHLER, "Handwörterbuch der reinen und angewandten Chemie," 10 v. (1842–50). Revised by Fehling as the "Neues Handwörterbuch . . . ," 10 v. (1871–1930).
MIALL, "Concise Chemical Dictionary," (1939).
MERCK and Co., "Merck's Index," 1940.
MUSPRATT, "Encyklopädisches Handbuch der technischen Chemie," 12 v. and 5 supls. (1888–1922).
NICHOLSON, "A Dictionary of Chemistry," (1795–1808).
THORPE, "Dictionary of Applied Chemistry," 7 v. and 3 supls. (1921–1936). Seventh edition started in 1937.
TURNER, "Condensed Chemical Dictionary" (1930).
TWENEY and SHIRSHOV, "Hutchinson's Technical and Scientific Encyclopedia," 4 v. (1935).
ULLMANN,[1] "Enzyklopädie der technischen Chemie," 10 v. and index (1928–1932).
URE, "A Dictionary of Arts, Manufactures and Mines," 4 v. (1867–1878).
VAN NOSTRAND Co., "Scientific Encyclopedia," (1938).
VILLAVECCHIA, "Dizionario di merceologia e di chimica applicata," 4 v. (1932).
WATTS, "A Dictionary of Chemistry," 6 v. (1872–1874). Revised by Morley and Muir, 4 v. (1888–1894).
WURTZ, "Dictionnaire de chimie pure et appliquée," 15 v. with supls. (1874–1908).

In addition to these encyclopedias dealing with chemistry, general encyclopedias, such as the "Encyclopaedia Britannica," frequently contain valuable discussions of chemical subjects.

The works known as almanacs provide another source of information of possible chemical value. These publications contain a wide variety of facts in tabular and graphic form. Since they often appear annually, they serve as supplements to the large encyclopedias. The following selection is representative:

1868–	"World Almanac."
1869–	"Whitaker's Almanack."
1885–	"Daily News Almanac."
1908–	"New International Yearbook."
1910–	"American Yearbook."
1923–	"American Annual."
1930–	"Statistical Abstract of the United States."

[1] The first supplement appeared under the title "Jahresberichte über die Patente und die technische Literatur der Industrielander, 1934."

C. Monographs

A monograph may be defined as a comprehensive summary of contemporary knowledge relating to a given subject.[1] The general nature of these publications has been indicated by the Board of Editors of the American Chemical Society Series of Scientific and Technologic Monographs in the following statement:

The development of knowledge in all branches of science, and especially in chemistry, has been so rapid during the last fifty years and the fields covered by this development have been so varied that it is difficult for any individual to keep in touch with the progress in branches of science outside his own speciality. In spite of the facilities for the examination of the literature given by *Chemical Abstracts* and such compendia as Beilstein's "Handbuch der organischen Chemie," Richter's "Lexikon der Kohlenstoff-Verbindungen," Ostwald's "Lehrbuch der allgemeinen Chemie," and Gmelin-Kraut's "Handbuch der anorganischen Chemie" and the English and French dictionaries of chemistry, it often takes a great deal of time to coordinate the knowledge available upon a single topic. Consequently, when men who have spent years in the study of important subjects are willing to coordinate their knowledge and present it in concise, readable form, they perform a service of the highest value to their fellow chemists.

Two rather distinct purposes are to be served by such monographs. The first purpose, whose fulfillment will probably render to chemists in general the most important service, is to present the knowledge available upon the chosen topic in a readable form, intelligible to those whose activities may be along a wholly different line. Many chemists fail to realize how closely their investigations may be connected with other work which, on the surface, appears far afield from their own. These monographs will enable such men to form closer contact with the work of chemists in other lines of research. The second purpose is to promote research in the branch of science covered by the monograph, by furnishing a well digested survey of the progress already made in that field and by pointing out directions in which investigation needs to be extended. To facilitate the attainment of this purpose, it is intended to include extended references to the literature, which will enable anyone interested to follow up the subject in more detail. If

[1] This statement is generally acceptable, although occasional publications of a different character are issued (for example, by the Carnegie Institution) under the title of "Monographs."

the literature is so voluminous that a complete bibliography is impracticable, a critical selection is made of those papers which are most important.

In one of the English series it is stated that monographs serve another purpose.

It is difficult in the case of the large treatises and textbooks to keep abreast of so rapidly a growing science by means of new editions. Monographs may be issued more frequently upon the various divisions of a general subject, each publication independent of and yet dependent upon the others, so that from time to time as new material and the demand therefore necessitates, a new edition of each monograph can be issued without reissuing the whole series. In this way, both the expenses of publication and the expense to the purchasers are diminished, and by a moderate outlay it is possible to obtain a full account of any particular subject as nearly current as possible.

Some publications which should properly be designated as monographs appear as separate contributions, entirely unrelated to any others; but works called monographs are issued usually as a series of books, written by individual authors under the direction of a general editor or board of editors.

Soule[1] has listed more than 30 series of monographs. In addition, there are in chemical libraries a considerable number of the books not called monographs which belong in this classification. In the list below representative selections of both of these groups are included, those from sets of monographs being marked.[2]

Agricultural Chemistry.—Associates of Rogers, "Fundamentals of Dairy Science" (5); Bailey, "Chemistry of Wheat Flour" (5); Clayton, "Margarine" (7); Gustavson, "Conservation of the Soil"; Jamieson, "Vegetable Fats and Oils" (5); Jensen, "Growth Hormones in Plants"; Sutermeister and Brown, "Casein and Its Industrial Applications" (5).

Analytical Chemistry.—Britton, "Conductometric Analysis"; Clark, "The Determination of Hydrogen Ions"; Feigl-Mathews, "Spot Tests"; Kolthoff and Rosenblum, "Acid-Base Indicators"; Prodinger, "Organische

[1] "Library Guide for the Chemist," p. 86 (1937).

[2] Series: 1. "Actualités scientifiques et industrielles." 2. "Die chemische Analyse." 3. "Einzelschriften zur chemischen Technologie." 4. "Kolloidforschung in Einzeldarstellungen." 5. "Monographs of the American Chemical Society." 6. "Monographs on Biochemistry." 7. "Monographs on Industrial Chemistry." 8. "Monographs on Inorganic and Physical Chemistry."

Fallungsmittel in der quantitativen Analyse" (2); Schoeller, "The Analytical Chemistry of Tantalum and Niobium."

Biochemistry.—Bayliss, "Enzyme Action" (6); Harden, "Alcoholic Fermentation" (6); Kayser, "Créatine et créatinine" (1); Levene and Bass, "Nucleic Acids" (5); Mitchell and Hamilton, "The Biochemistry of the Amino Acids" (5); Northrop, "Crystalline Enzymes"; Peters, "Body Water"; Sherman and Smith, "Vitamins" (5).

Industrial Chemistry.—Bone, "Coal and Its Scientific Uses" (7); Burk, Thompson, Weith, and Williams, "Polymerization" (5); Curtis, "Fixed Nitrogen" (5); Miller, "Chemische Technologie des Glasses" (3); Morey, "Properties of Glass" (5); Teeple, "Industrial Development of Searles Lake Brines" (5); Vail, "Soluble Silicates in Industry" (5); Zimmer and Cameron, "Nitrocellulose Ester Lacquers."

Inorganic Chemistry.—Archibald, "Preparation of Pure Inorganic Substances"; Desch, "Intermetallic Compounds" (8); Franklin, "Nitrogen System of Compounds" (5); Hume-Rothery, "The Structure of Metals and Alloys"; Quinn and Jones, "Carbon Dioxide" (5); Sosman, "Properties of Silica" (5); Spencer, "Metals of the Rare Earths" (8).

Metallography.—Elam, "Distortion of Metal Crystals"; Fuss and Anderson, "Metallography of Aluminum and Its Alloys"; Gulliver, "Metallic Alloys"; Pulsifer, "Structural Metallography"; Schimmel, "Metallography of Industrial Copper Alloys."

Metallurgy.—Burns and Schuh, "Protective Coatings for Metals" (5); Corse, "Bearing Metals and Bearings" (5); Gregg, "Arsenical and Argentiferous Copper" (5); Mantell, "Tin"; McKay and Worthington, "Corrosion Resistance of Metals and Alloys" (5); Smythe, "Lead" (7).

Organic Chemistry.—Egloff, "Reactions of Pure Hydrocarbons" (5); Fieser, "Chemistry of Natural Products Related to Phenanthrene" (5); Hurd, "The Pyrolysis of Organic Compounds" (5); Ipatiev, "Catalytic Reactions at High Pressures and Temperatures"; Karrer, "Polymere Kohlenhydrate" (4); Rice and Rice, "Aliphatic Free Radicles"; Sidgwick, "Organic Chemistry of Nitrogen."

Pharmaceutical Chemistry.—Burn, "Biological Standardization"; Clark, "Action of Drugs on Cells"; Finnemore, "The Essential Oils"; Henry, "The Plant Alkaloids"; Kendall, "Thyroxine" (5); Von Oettingen, "Therapeutic Agents of the Quinoline Group" (5).

Physical Chemistry.—Aston, "Mass Spectra and Isotopes"; Debye, "Polar Molecules"; Gurney, "Ions in Solution"; Hibben, "The Raman Effect and Its Chemical Applications" (5); Hildebrand, "Solubility of Non-Electrolytes" (5); Kistiakowsky, "Photochemical Processes" (5); Pauling, "The Nature of the Chemical Bond"; Weiser, "The Colloidal Elements"; Wyckoff, "The Structure of Crystals" (5).

TEXTBOOKS

There remains a large, heterogeneous mass of books which do not properly come under the headings already discussed. Such

books are neither bibliographies, indexes, handbooks, treatises, dictionaries, encyclopedias, nor monographs, considered from the viewpoint of the use of these terms, as already given. To designate the publications constituting this remaining class, the word textbook has been adopted, and it is used in the sense of signifying a manual of instruction.

It is recognized that no sharp line can be drawn to differentiate all the classes considered in this chapter. Indexes stand apart rather distinctly; but monographs merge into treatises, treatises into encyclopedias, and textbooks into monographs. Also some works called textbooks by their authors are really treatises, in the sense that the terms are used here.

Monographs present, more or less, an exhaustive summary of contemporary knowledge for special subjects, but often omit many of the details which are chiefly of historical interest; treatises correspond somewhat to this but are more comprehensive in their subject matter, generally including an entire division of chemistry, as inorganic; encyclopedias consist of a collection of short summaries on the more significant topics in the whole field of chemistry, or a large portion of it. Textbooks, on the other hand, are more selective, and less exhaustive and comprehensive.

If we assume that textbooks are manuals of instruction, it is obvious that the primary aim in producing such a work is to have it serve for instructional purposes. It is now recognized that, as a rule, such a book should not be detailed in nature, but rather should be arranged to be representative of principles. We expect to find in a textbook a presentation of the general principles of the field to be covered, accompanied by sufficient descriptive and explanatory matter, and often problems, to impress the desired points upon the student.

Textbooks, as ordinarily written, seldom represent the writer's own contributions. He has searched the field which the book is designed to cover and selected those principles, facts, and theories which seem to him desirable to include. These gleanings are then arranged in whatever order is desired. The author's main function is to select, arrange, and discuss.

In general, textbooks are produced by one or two authors. The usual practice of publishers is to issue these books as separate

publications, rather than in the form of a publisher's series under a general editorship. We have, however, several excellent examples of the latter procedure, such as the McGraw-Hill series, edited by J. F. Norris, and the English series on physical chemistry, originally edited by Sir William Ramsay.

Not all textbooks are written to cover a subject in the same way, and three more or less distinct types may be recognized. Some are designed to serve simply as a source of directions for carrying out given work in the laboratory. The nature of their contents is frequently indicated by the title, such as "Laboratory Manual of Colloid Chemistry," or "Experimental Organic Chemistry." Others are given over entirely to a presentation of descriptive and theoretical matter. A very considerable number represent a combination of the foregoing types, containing descriptive and theoretical matter, together with directions for performing experiments and determinations relating to or illustrating the other portion of the text.

With the multitude and variety of works available that may be considered as textbooks, covering practically every phase of chemical activity and printed in many languages, it is obviously impossible, and probably not desirable, to try to make a list of the satisfactory ones obtainable. What would be a satisfactory book for one purpose might well be quite unsuitable for another. What one individual would consider a good book for certain purposes, another person would not use. Also a book that was authoritative when issued may now be far behind present practice. Some books are intended to be only elementary and for the use of beginning students; others are for advanced study, and tend toward the nature of a reference work in including material more detailed, more comprehensive, and often more difficult to grasp.

Since some of the more important periodicals, institutional publications, and general reference works have had specific mention, there is included here a short list of some of the current textbooks and smaller reference books in various fields of chemistry. It should be kept in mind that the list is only partial and intended to be merely representative. It should not be assumed, because a book is included, that it is considered the best or latest

in its field. Mostly, works in the English language are included, since they are the usual textbooks in this country.

Selected List[1] of Textbooks

Agricultural Chemistry.—Anderson, "Essentials of Physiological Chemistry"; Czapek, "Biochemie der Pflanzen"; Dutcher and Haley, "Agricultural Biochemistry"; Gortner, "Outlines of Biochemistry"; Hedges, "Application of Chemistry to Agriculture"; Knowles and Watkins, "Agricultural Chemistry"; Russell, "Soil Conditions and Plant Growth."

Analytical Chemistry (Qualitative).—Curtman, "Qualitative Chemical Analysis"; McAlpine and Soule, "Prescott and Johnson's Qualitative Chemical Analysis"; Middleton and Willard, "Semi-micro Qualitative Analysis"; Noyes and Bray, "A System of Qualitative Analysis for the Rarer Elements"; Treadwell-Hall, "Analytical Chemistry," Vol. I.

Analytical Chemistry (Quantitative).—Fales and Kenny, "Inorganic Quantitative Analysis"; Griffin, "Technical Methods of Analysis";[2] Kolthoff and Furman, "Volumetric Analysis," 2 v.; Kolthoff and Sandell, "Textbook of Quantitative Inorganic Analysis"; Mahin, "Quantitative Analysis"; Mellon, "Methods of Quantitative Chemical Analysis"; Smith, "Analytical Processes"; Sutton, "Volumetric Analysis"; Willard and Furman, "Elementary Quantitative Analysis."

Biological Chemistry.—Bodansky, "Introduction to Physiological Chemistry"; Cameron, "Textbook of Biochemistry"; Harrow and Sherwin, "Textbook of Biochemistry"; Hawk and Bergeim, "Practical Physiological Chemistry"; Mathews, "Physiological Chemistry."

General Chemistry.—Brinkley, "Principles of General Chemistry"; Briscoe, "General Chemistry for Colleges"; Deming, "General Chemistry"; Foster, "Inorganic Chemistry for Colleges"; McCutcheon, Selz, and Warner, "General Chemistry"; McPherson and Henderson, "General Chemistry"; Norris and Young, "Inorganic Chemistry"; Timm, "An Introduction to Chemistry."

History of Chemistry.—Brown, "History of Chemistry"; Kopp, "Geschichte der Chemie"; Meyer, "A History of Chemistry"; Moore-Hall, "A History of Chemistry"; Partington, "Origins and Development of Applied Chemistry"; Smith, "Chemistry in America"; Weeks, "Discovery of the Elements."

Industrial Chemistry.—Badger and McCabe, "Elements of Chemical Engineering"; Martin, "Industrial and Manufacturing Chemistry"; Ost, "Lehrbuch der chemischen Technologie"; Read, "Industrial Chemistry"; Riegel, "Industrial Chemistry"; Walker, Lewis, McAdams, and Gilliland, "Principles of Chemical Engineering."

Inorganic Chemistry.—Emeleus and Anderson, "Modern Aspects of Inorganic Chemistry"; Ephraim, "Textbook of Inorganic Chemistry";

[1] For others see lists of books, p. 150.

[2] A valuable list of publications is included.

Hopkins, "Chapters in the Chemistry of the Less Familiar Elements"; Mellor, "Modern Inorganic Chemistry"; Morgan and Burstall, "Inorganic Chemistry"; Partington, "Textbook of Inorganic Chemistry"; Remy, "Lehrbuch der anorganischen Chemie."

Metallography.—Bullens, "Steel and Its Heat Treatment"; Desch, "Metallography"; Doan, "Principles of Physical Metallurgy"; Hoyt, "Metallography"; Kehl, "Principles of Metallurgical Laboratory Practice"; Sauveur, "Metallurgy and Heat Treatment of Iron and Steel"; Williams and Homerberg, "Principles of Metallography."

Metallurgy.—Camp, "The Making, Shaping and Treating of Steel"; Carpenter and Robertson, "Metals"; Guillet, "Les métaux legers et leurs alliages"; Hayward, "Outline of Metallurgical Practice"; Megraw, "Flotation"; Stoughton, "Metallurgy of Iron and Steel."

Organic Chemistry.—Bernthsen, "A Textbook of Organic Chemistry"; Conant, "The Chemistry of Organic Compounds"; Desha, "Organic Chemistry"; Hückel, "Theoretische Grundlagen der organischen Chemie"; Karrer, "Lehrbuch der organischen Chemie"; Lucas, "Organic Chemistry"; Norris, "Principles of Organic Chemistry"; Schlenk, "Ausführliches Lehrbuch der organischen Chemie," Whitmore, "Organic Chemistry." (Many facts, in highly condensed form, are contained in "An Outline of Organic Chemistry" by Degering, Nelson and Harrod.)

Pharmaceutical Chemistry.—Bentley and Driver, "Textbook of Pharmaceutical Chemistry"; May and Dyson, "Chemistry of Synthetic Drugs"; Rogers, "Inorganic Pharmaceutical Chemistry"; Sadtler, Coblentz, and Hostmann, "Pharmaceutical and Medical Chemistry"; Schmidt, "Ausführliches Lehrbuch der pharmazeutischen Chemie."

Physical Chemistry.—Eggert and Gregg, "Physical Chemistry"; Eucken, "Grundriss der physikalischen Chemie"; Getman and Daniels, "Outlines of Theoretical Chemistry"; Lewis, "A System of Physical Chemistry"; MacDougall, "Physical Chemistry"; Noyes and Sherrill, "Chemical Principles"; Taylor, "Treatise on Physical Chemistry"; Taylor and Taylor, "Elementary Physical Chemistry"; Webb, "Elementary Principles in Physical Chemistry."

For other works, both in the fields already indicated and in others more specialized, the student is referred to the following publications:

1. *Chemische Novitäten*, a periodical listing new foreign books (1904+).
2. Catalogues of publishing houses and dealers in books,[1] such as John Wiley & Sons, Inc., McGraw-Hill Book Company, Inc., D. Van Nostrand Company, Inc., Longmans, Green & Company, B. Westermann Company, G. E. Stechert & Company, Henry Sotheran and Company, Gustav Fock, and Masson et Cie.

[1] For a more extensive list, see Crane and Patterson, "The Literature of Chemistry," Appendix 7 (1927).

3. General lists of books, such as
   a. The Technical and Scientific Books Section of the "Chemical Engineering Catalog." This is "a practically complete list of books in the English language dealing with those subjects in which the users of the Chemical Engineering Catalog are likely to be interested." About 2600 volumes are listed alphabetically by authors. An elaborate subject index is provided, but there are few annotations indicating the contents or worth of the books.
   b. Bolte, "Führer durch die chemische Literatur für Wissenschaft und Praxis." This is a list of the most important German chemical and chemicotechnological books. The material is classified and includes annotations regarding the content of each book, but no comment is made regarding their relative value.
   c. British Science Guild, "Catalogue of British Scientific and Technical Books."
   d. Olsen, "Chemical Annual." In a section entitled New Books there is given in each edition a list of the more important books listed since the previous edition. Classified lists of American, British, French, and German books are included, arranged alphabetically by authors. No annotations regarding content or worth are given.
   e. Crane and Patterson, "The Literature of Chemistry," Appendix 8 (1927). This is probably the most valuable single list. Although less comprehensive than certain other lists (1685 entries included), it has the great merit of containing many annotations regarding the value of a given book. Furthermore, with the advice of experts in various phases of chemistry and the assistance of several technical librarians, in each of the classified lists certain books are marked with one or two asterisks to indicate that they are important or most important, respectively. The material is first classified according to the sections used in *Chemical Abstracts* and then further subdivided. The list now needs revision.
   f. Section XII, Bibliography, of "Chemical Industries," the British publication. A classified list of over 2000 books is included.
   g. Rimbach, "How to Find Metallurgical Information." A list of over 1000 books, with a detailed subject index, is part of Rimbach's compilation. Although intended for metallurgists, it is of value to the chemist and chemical engineer.

In addition to the foregoing lists, devoted to chemical or general scientific and technical books, there are available, in the better libraries, comprehensive lists of all kinds of publications. In general, each of these is confined to a given language or country; and a given volume will include the works in print at the time of its publication, or those issued during a specified period. Some of the important lists are indicated.

American:[1]

"Cumulative Book Index" (formerly "The United States Catalogue," cumulated at various periods).
"Publishers' Trade List Annual" (a collection of the catalogues of American publishers).
"Technical Book Review Index."
"Technical Books of All Publishers" (Chem. Pub. Co.).

British:

"English Catalogue of Books" (annual).
"Whitaker's Cumulative Book List" (quarterly and annual).
"Reference Catalogue of Current Literature" (biennial list of books in print).

French:

"Biblio" (monthly).
"La Librairie Française" (annual).

German:

"Deutsche Nationalbibliographie" (weekly).
"Halbjahrsverzeichnis der Neuerscheinungen des deutschen Buchhandels" (semiannual).

[1] Also see MUDGE, "Guide to Reference Books."

CHAPTER IX

SECONDARY SOURCES—MISCELLANEOUS COMPILATIONS

Books are faithful repositories, which may be awhile neglected or forgotten; but when they are opened again, will again impart their instruction—*Johnson.*

There remain a variety of miscellaneous secondary sources which might, perhaps, be included as a subdivision of the preceding chapter, since the publications are, in a sense, works of reference. However, they seem, for the most part, to be sufficiently different to justify separate consideration.

The works included here are often of more use to nonchemists than to those practicing the profession. To some chemists they may be of no use; but to others, especially those in industry, the information presented may be of great assistance.

In practically all cases the information compiled consists of an orderly arrangement of simple facts. Only in the recipe books do the facts consist of directions for performing chemical processes.

1. Recipe Books.—As a result of the work of manufacturing chemists and practical experimenters, there has been accumulated an extensive collection of formulas and recipes (receipts) consisting of directions for performing given reactions or making certain products. In general, such information is intended to be distinctly practical in nature, with emphasis on commercial methods. In the following representative publications a large variety of recipes may be found:

Am. Pharm. Assoc., "National Formulary."
Am. Pharm. Assoc., "The Pharmaceutical Recipe Book."
Bennett, "Practical Everyday Chemistry."
Bennett, "Cosmetic Formulary."
Bennett, "The Chemical Formulary," 4 v.
Fiene and Blumenthal, "Handbook of Food Manufacturing."

Hopkins, "Scientific American Cyclopedia of Formulas."
Jameson, "Jameson's Manufacturers' Practical Recipes."
Sloane, "Henley's Twentieth Century Formulas, Recipes and Processes."
Wooley and Forrester, "Pharmaceutical Formulas," 2 v.
———, "Recipes for the Color, Paint, Varnish, Oil, Soap and Drysaltery Trades."
———, "Workshop Receipts," 5 v.

2. Catalogues.—Like the modern drugstore, these publications contain a collection of items one may or may not find easily elsewhere. Included in these sources is information such as directories of manufacturers and dealers, trade names, advertising data and descriptions of equipment, lists of chemicals and chemical products, specifications for given items for particular purposes, and other related items. Some of these guides to sources of products used, or produced, by chemical industry are described briefly in the following paragraphs.

"Blue Book" (Soap and Sanitary Chem. Co.).—This buyer's guide includes raw materials, equipment, and products. An appendix covers specifications, testing, and miscellaneous information.

"Blue Price List Section" (*American Druggist*).—In an annual supplement the *American Druggist* lists pharmaceutical products and supplies.

Brady, "Materials Handbook."—Over 2400 materials (metals, alloys, refractories, abrasives, woods) are listed, including their chief characteristics, comparative data, sources, substitutes, adulterants, and uses.

"British Chemicals and Their Manufacturers."—This official directory of the Association of British Chemical Manufacturers lists chemicals with their proprietary and trade names. In addition to the English name, those for five other languages are given, together with the names of the concerns manufacturing the material and its industrial uses.

"Buyers Guidebook" (*Chem. Industries, Inc.*).—In October of each year this work appears in connection with the periodical *Chemical Industries*. It is an extensive compilation covering several years of back prices; trade and technical associations; a geographical list of companies; a buying guide for raw materials, chemicals, and specialties; and brands, names, and synonyms. Condensed information is included for each product listed, including the names of dealers and manufacturers.

"Chemical Engineering Catalog" (*Reinhold Pub. Co.*).—This process industries catalogue is a valuable collection of condensed data on equipment, machinery, laboratory supplies, and chemicals and raw materials used in the industries employing chemical processes of manufacture. There is an extensive list of scientific and technical books arranged alphabetically by authors, with an elaborate subject index.

"Drug and Cosmetic Review" (*Drug and Cosmetic Ind.*).—This is another compilation of miscellaneous information on druggist's supplies.

"Green Book" (Oil, Paint and Drug Reporter).—This is a buyer's directory listing industrial materials, industrial equipment and supplies, professional services, trade and brand names, and imports and exports of selected chemicals for the two years preceding the year of publication.

Gregory, "Uses and Applications of Chemicals and Related Materials."—Gregory's compilation of uses and applications covers over 5000 substances. The data include synonyms, foreign names, classification of uses by industries, and many patent references. Supplementary surveys are promised in the *Oil, Paint and Drug Reporter.*

Gutman, "Modern Drug Encyclopedia."—This work is somewhat less a collection of trade information than the other pharmaceutical works mentioned.

Haynes, "Chemical and Raw Material Directory."—Nearly 5000 firms and individuals making or selling chemicals and chemical raw materials are listed alphabetically. The information included in this directory service is "essential business data."

"New and Nonofficial Remedies" (Am. Med. Assoc.).—General information on the composition and uses of new remedies is presented.

Newitt, "Chemical Industries."—Something of a cross between the "Chemical Engineering Catalog" and the "Chemical Engineers' Handbook," Newitt's compilation covers materials of construction, power plants, factory equipment layout and location, unit process machinery, instruments and laboratory apparatus, raw materials, and heavy chemicals. An extensive list of books is included.

"Oil Refinery Equipment" (Gulf Pub. Co.).—This is another process handbook listing equipment especially for the petroleum industry. An important section covers engineering data and flow sheets for different processes.

"Pit and Quarry Handbook" (Complete Service Pub. Co.).—This process handbook is a combination of technical reference book, trade directory, and consolidated catalogues.

"Process Industries Handbook" (Chem. & Met. Eng.).—For each of a wide variety of process industry materials there are given the manufacturer, chemical composition, physical properties, corrosion data, and other information of interest to chemical engineers.

"Red Book Price List Section" (Druggist's Circular).—This annual supplement to the *Druggist's Circular* is similar to other works of its type.

Snell and Snell, "Chemicals of Commerce."—In this classified compilation the material is arranged to bring related substances together. For the commercially important synthetic and natural inorganic and organic materials there are included the scientific, technical and common facts of most likely value in processing, manufacturing and using these materials.

"Sweet's Catalogue File" (F. W. Dodge Co.).—This work, for the process industries, is a collection of manufacturer's catalogues for producers of raw bulky materials.

Wenzel, "Adressbuch und Warenverzeichnis der chemischen Industrie des deutschen Reichs."—German chemical manufacturers and their products are listed.

Catalogues of Chemicals.—Manufacturers' or distributors' catalogues are useful sources of information on the availability and comparative prices of many common chemicals. Generally specifications are included for "analytical" or "reagent quality" materials. The following manufacturers are typical of those having such catalogues (firms marked by asterisks are primarily pharmaceutical):

*Abbott Laboratories, N. Chicago, Ill.
*Eli Lilly Co., Indianapolis, Ind.
E. I. du Pont de Nemours and Co., Wilmington, Del.[1]
*E. R. Squibb and Sons, New York City.
Eastman Kodak Co., Rochester, N. Y. (fine organic chemicals).
General Chemical Co., New York City.
J. T. Baker Chemical Co., Phillipsburg, N. J.
Mallinckrodt Chemical Works, St. Louis, Mo.
Merck and Co., Rahway, N. J.
*Sharpe and Dohme, Baltimore, Md.

3. Biographical Works.—Many occasions arise when one wants biographical data about chemists. For those who are best known, such information can generally be found in works of the "Who's Who" type. The following list of books includes the names of many chemists and chemical engineers:

Barth, "Poggendorff's Biographisch-literarisches Handwörterbuch."
Cattell and Cattell, "American Men of Science."
———, "Dictionary of American Biography" (Scribner's Sons).
Haynes, "Chemical Who's Who."
"The International Who's Who" (Europa Pblns.).
Leonard, "Who's Who in Engineering."
Marquis, "Who's Who in America."
Thomas, "Universal Pronouncing Dictionary of Biography."
———, "Who's Who in Education" (Cook Pub. Co.).

[1] The "Du Pont Products Index" lists physical properties, uses and containers.

CHAPTER X

MAKING SEARCHES IN THE CHEMICAL LITERATURE

Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it.—*Johnson.*

In case one desires information on some chemical subject, the first question arising is that of where to go to find publications such as those discussed in the preceding chapters. In general, it may be assumed that some publications will be found wherever progressive chemists are located or where there is a demand for chemical facts. But in spite of the present supply of books and periodicals, it is surprising to find the handicap under which some individuals work in this respect. An instance comes to mind of a laboratory employing five or six so-called chemists, none of whom could read anything in a foreign language; and in addition no periodicals were being received in the laboratory.

Location of Publications.—Disregarding the private collections of individual chemists, one turns naturally to our libraries as the most probable source of the desired material. Although we have in this country hundreds of libraries, it is probably safe to state that the majority of them are of relatively little value to one needing much chemical information. Most of those in the smaller colleges and the smaller cities may be disregarded. A really good, general chemical library is expensive, not only to acquire, but also to maintain; consequently, the situation mentioned is not unexpected, if one keeps in mind the limited funds available in most cases for the support of the whole library.

The libraries in this country which do have really worthwhile collections of chemical publications may be classified as public, private, and those belonging to educational institutions. Probably no one of these classes in itself possesses any particular merit when compared with the other two, for there are excellent and mediocre collections in each.

As a part of the material included in their "List of Periodicals" the editors of *Chemical Abstracts* mention 255 libraries in the United States and Canada having the best chemical collections. Read[1] estimates that about 80 of these are really important. Crane and Patterson[2] have included in their book a list of 79 American libraries of interest to chemists. A number of valuable collections, however, have been omitted in this work.

Public Libraries.—It is probably safe to state that, as a rule, there are few collections of much significance in the public libraries of cities having a population of less than 100,000. Of course, it must not be assumed from this arbitrary limitation that mere numbers in population assure a good library; but, ordinarily, the larger the city the greater is the demand for such material, and the greater is the possibility of finding a well-developed technological department. The superb collection of the Congressional Library at Washington represents one of the most nearly complete collections in this class. The various state and federal libraries would be included here, although some few are not open to the general public.

Private Libraries.—Of the private libraries of significance in this connection, two rather distinct types will be recognized, the scientific and the industrial. The former are maintained, usually, by means of private endowments or through some club or professional organization or society. Examples of such institutions are the Case Library in Cleveland, and the libraries of the Chemists' Club[3] and the Franklin Institute in New York and Philadelphia, respectively. Such libraries are usually available to those maintaining membership in the organization or contributing to its support in some way. The courtesy of working in such collections is frequently extended to other persons properly qualified.

The private libraries which may properly be designated as of the industrial type are those maintained in connection with manufacturing, consulting, and research organizations, such as the General Electric Company, the consulting laboratory of

[1] "Industrial Chemistry," p. 18 (1938).

[2] "The Literature of Chemistry," Appendix 3 (1927).

[3] This collection, containing over 50,000 volumes, is the largest exclusively chemical library in the western hemisphere.

A. D. Little, and the Mellon Institute of Industrial Research. Admirable collections of publications are available in a number of these organizations, the library of the E. C. Worden consulting laboratory at Millburn, N. J., comprising nearly 20,000 volumes on chemical literature. Some of these collections are very specialized, covering only limited fields of applied chemistry, while others cover more or less the whole field of chemistry. Although this material is primarily for the use of individuals connected with the organization maintaining the library, it is frequently possible for outsiders to obtain permission to consult the publications.

Libraries of Educational Institutions.—In the 600 or 700 colleges and universities in this country probably less than 20 per cent have chemical collections of much significance for general work. A few of the smaller institutions are well equipped, occasionally an unusual collection being found, as in the Hooker Scientific Library at Central College, Mo.;[1] but for the most part the best libraries are at the larger institutions, and particularly at those where much attention is devoted to graduate work. In general, chemists outside the institution may make arrangements to consult such libraries.

As an indication of the relative distribution of the several types of libraries, the following percentages have been calculated for the list of 255 libraries mentioned above: governmental, 8.3; public, 20.0; private, scientific, 6.6; private, industrial, 10.2; and educational institutions, 54.9.

Interlibrary Loans and Photographic Service.—In doing investigational work many individuals will not be so situated as to have available a good chemical library; or even if they are, certain publications will not be found. Many of the libraries mentioned in the list referred to above have relatively incomplete collections, and it is frequently a problem to obtain some special publication, particularly early volumes of the older periodicals. In such cases it is often possible to take advantage of the interlibrary service maintained in many places. Unless the publication desired forms part of an expensive or rare set, or is in frequent demand in the library possessing it, one generally

[1] See *Record Chem. Progress*, **1**, 1 (1939).

can have a nearby library borrow it for a short time. In the case of short articles, or when it seems unwise to take the chance of having a valuable book lost or damaged, photographic copies of the desired parts may be made at relatively small expense.[1] Most of the larger libraries are equipped for making full-page-size reproductions known as photostats. In 1937 a new copying service became available, the reproductions being known as filmstats (or bibliofilm). Standard 35-mm. film is used, and generally each "frame" will be a page of the publication photographed. At present the American Documentation Institute (of Science Service) Washington, D. C., is supplying filmstats of material in the principal libraries of that city at a service charge of 20 cents per article plus 1 cent per page. To read the film some kind of magnifying device is required.[2] Some individuals prefer to go to a good library rather than to depend upon borrowing publications or obtaining copies of them. In addition to the services mentioned above, a few libraries are able to supply translations of material in foreign languages.

In the "List of Periodicals" abstracted by *Chemical Abstracts* one may find whether the libraries mentioned there have at least a partial file of a given periodical. In certain cities union lists have been compiled, which give similar information for the libraries included in the region covered. Still more comprehensive is the "Union List of Serials" for libraries of the United States and Canada.

Finding Publications in a Library[3]

For the efficient use of the many publications constituting the chemical literature, it is necessary to have, in the first place, an orderly arrangement of the publications in the library, together with some means for finding them easily. It is insufficient merely to assemble the material by placing separate

[1] This service is especially valuable any time one desires an accurate copy of complicated features such as formulas, diagrams, and tables.

[2] Commercial copying and reading equipment are now available.

[3] See the following pamphlets by the H. W. Wilson Company, New York City: "So This Is the Catalog"; "How to Find Material on a Subject"; and "Time Savers—Periodical Indexes."

publications side by side on a shelf. Fortunately, librarians have devised systems of arrangement which are relatively easy to understand and use.

Arrangement of Publications.—Publications are arranged in a library according to some definite scheme, so that those possessing more or less common characteristics are grouped together. Although various bases of classification may be used, for general work the material is most satisfactorily arranged according to subjects. In carrying out this scheme the Dewey Decimal Classification is probably most widely used. In accordance with this system, the works covering all branches of knowledge are divided into ten main divisions, designated with Arabic numerals, as shown below:

000 General works (bibliography, encyclopedias, general periodicals).
100 Philosophy (psychology, ethics).
200 Religion (Bible, church history).
300 Sociology (economics, education).
400 Philology.
500 Natural science (mathematics, physics, chemistry, biology).
600 Useful arts (architecture, engineering, agriculture).
700 Fine arts.
800 Literature.
900 History (travel, biography).

For convenience these classes are usually referred to as hundreds rather than units; *e.g.*, the 500's mean the sciences.

Each of these classes may be divided and subdivided, by the addition of other figures, to an almost unlimited extent. Thus, 900 being history, 970 stands for the history of America, 973 for the history of the United States, 977 for the history of the north central states, 977.2 for the history of Indiana, and 977.295 for the history of Tippecanoe County.

Each book, as it comes to the library, is given a number that corresponds as closely as possible to its subject, and all books having the same number are shelved together.

To distinguish books on the same subject but written by different authors, another symbol is used, called the author number[1] or book number. This consists of a letter followed by one or more figures; *e.g.*, in 977.2 D92, History of Indiana by

[1] Sometimes called the Cutter number (from the Cutter author classification).

J. P. Dunn, and 977.2 M78, History of Indiana by E. E. Moore, D92 and M78 stand for the surnames Dunn and Moore, respectively. In addition, the book number may contain other entries to indicate title, edition, language, or translator.

In the general placing of books on the shelves they are arranged from left to right, first according to their class numbers, and then books with the same class numbers according to their author numbers.

The classification number 977.2 and the book number D92, taken together, are spoken of as the call number, since by means of this symbol the book can be located on the shelf by the librarian, or the reader himself, and thus obtained for use. This call number is written on and in each volume on the shelves. It appears also in the upper left-hand corner of the card in the card catalogue, which is discussed later. When written down for reference or when calling for a book, it should be copied accurately and completely.

The following abridged classification indicates the chief classes of publications that contain information of chemical interest, the Dewey number being shown on the left.

ABRIDGED SYSTEMS OF CLASSIFICATION

Dewey		Library of Congress
000	General works:	*A*; *Z*
016.54	Bibliography of chemistry.	*Z* 5521–5526
300	Sociology:	*H*
310	Statistics:	*HA*
317.3	U. S. Bureau of the Census.	*HA* 201
340	Law:	*K*
340.6	Legal chemistry.	*RA* 1001
370	Education:	*L*
371.66	Laboratory equipment.	*Q* 183
389	Weights and measures.	*QC* 81–119
500	Natural science:	*Q*
510	Mathematics:	*QA*
530	Physics:	*QC*
530.85	U. S. Bureau of Standards.	*QC* 100
535	Light.	*QC* 351–495
535.84	Spectroscopy.	*QC* 451–467
536	Heat.	*QC* 251–338
537	Electricity.	*QC* 501–771
537.85	Electrometallurgy.	*TN* 681–687

Dewey		Library of Congress
539	Molecular physics.	*QC* 173
540	Chemistry:	*QD*
541	Theoretical and physical.	*QD* 453–655
542	Practical and experimental.	*QD* 43–64
543	Analytical, general.	*QD* 71–80
544	Analytical, qualitative.	*QD* 81–100
545	Analytical, quantitative.	*QD* 101–150
546	Inorganic.	*QD* 151–247
547	Organic.	*QD* 248–449
548	Crystallography.	*QD* 901–999
549	Mineralogy.	*QE* 351–399
550	Geology:	*QE*
551.94	Geochemistry.	*QE* 515
557.3	U. S. Geological Survey.	*QE* 75–76
570	Biology, general:	*QH* 301–705
578	Microscopy.	*QH* 201–277
600	Useful arts:	*T*
608	Patents, inventions.	*T*201–339; *TP* 210
610	Medicine:	*R*
612	Physiology.	*QP*
612.015	Physiological chemistry.	*QP* 501–801
614	Public health.	*RA*
614.09	U. S. Public Health Service.	*RA* 11
615	Materia medica, pharmacy.	*RS*
620	Engineering, general:	*TA*
621.35	Chemical electricity.	*QC* 603–605
622	Mining engineering.	*TN*
622.09	U. S. Bureau of Mines.	*TN* 1
628	Sanitary engineering.	*TD*
630	Agriculture:	*S*
630.24	Agricultural chemistry.	*S* 583–588
630.72	Work of experiment stations.	*S* 31–132
631	Soils and fertilizers.	*S* 631–667
637	Dairy and dairy products.	*SF* 221–275
640	Domestic economy:	*TX*
641.1	Food, chemically considered.	*TX* 501–572
660	Chemical technology:	*TP*
661	Chemicals.	*TP* 200–248
662	Explosives.	*TP* 268–299
663	Beverages.	*TP* 500–618
664	Foods.	*TP* 370–465
665	Oils, gas.	*TP* 343–360
666	Ceramics, glass.	*TP* 785–889
667	Bleaching, dyeing.	*TP* 890–932
668	Other organic industries.	?
669	Metallurgy, assaying.	*TN* 550–799

Dewey		Library of Congress
670	Manufactures, articles made of:	*TS*
671	Metals.	*TS* 200–770
672	Iron and steel.	*TS* 300–380
673	Brass and bronze.	*TS* 564–589
674	Wood.	*TS* 800–910
675	Leather.	*TS* 940–1047
676	Paper.	*TS* 1080–1220
677	Textiles.	*TS* 1300–1781
678	Rubber.	*TS* 1870–1920
679	Celluloid.	*TP* 986. *C5*
690	Building:	*TA*; *TT*
691	Materials, processes.	*TA* 401–492
698	Painting, glazing.	*TT* 300–380
700	Fine arts:	*N*
770	Photography.	*TR*
900	History:	*D*
920	Biography.[1]	*QD* 21–22

[1] Chemists only.

Each Dewey class may have subdivisions, as .03 for dictionaries, .05 for serials, and .06 for society publications. For further details concerning this system, the reader is referred to Dewey's "Decimal Classification and Relative Index for Libraries."

Another system of classification, which is particularly suited for large libraries, is that used in the Library of Congress, the Mellon Institute for Industrial Research, the Chemists Club in New York, and others.[1] "LC" call numbers are shown above. According to this scheme, the general fields of knowledge are designated by letters, Class Q being science. A second letter is used to differentiate the divisions of each class, QD being chemistry; QP, physiological chemistry; TP, chemical technology; RS, medical and pharmaceutical chemistry; and S, agricultural chemistry. Details regarding this system may be found in the "Library of Congress Classification," available in libraries or obtainable from the Superintendent of Documents at Washington, D. C.[2]

In addition to the two foregoing systems, some librarians have devised special systems of their own or modified one of the

[1] See MASON, *J. Chem. Education*, **7**, 1887 (1930), for a discussion of the reclassification of a chemistry library according to the Library of Congress system.

[2] Also REID, "Introduction to Organic Research," p. 118 (1924).

more generally used schemes in order to adapt it to special situations.

The Card Catalogue

The card catalogue serves as an index or guide to the publications contained in a library just as the index of a book enables one to find what is contained therein. In making such catalogues, the practice of different librarians varies somewhat. In many cases the catalogue is a single file consisting of a list of the publications by author, by title, and by subject, all in one alphabetical arrangement. In such a case it is known as a dictionary card catalogue. Under an individual's name will be found a list of the works he has written, or works written about him which the library possesses. Again, for each publication dealing with a specific subject, a card is placed in the catalogue under the name of that subject, thus bringing together in one place all references dealing with that subject. The following example indicates the method of indexing a publication when the headings on the cards are for (1) author, (2) title, and (3) subject:

(1) 541.39	Sabatier, P.
Sa1	Catalysis in organic chemistry.
(2) 541.39	Catalysis in organic chemistry.
Sa1	Sabatier, P.
(3) 541.39	Organic chemistry, catalysis in.
Sa1	Sabatier, P.

If no author is given or if the title is a significant one, a card is included for the title. From the card catalogue one can ascertain at once the publications in the library on a given subject, with a certain title, or by a particular author. In using the catalogue one searches in the proper alphabetical place for the author's name, or the title or subject of the publication desired, making use of the letters on the front of the drawers and the guide cards inside. Each catalogue card, whether its heading is for author, for title, or for subject, furnishes part or all of such information as the following:

Author's full name (government, society, or institution).
Title of publication.
Call number (in upper left-hand corner).
Number of pages, size of book, illustrations.

Publisher, date, and place of publication.
Descriptive and bibliographical notes, table of contents.

The accompanying example of a catalogue card is the one prepared for the first edition of this book by the Library of Congress.[1] The typed notation is the call number for the Dewey system, the card being intended for an "author" entry. Cards which are entirely typed usually contain less information than the Library of Congress cards. On the lower half of the card are shown (1) each of the more important subjects under which the book should be catalogued (*A*); (2) the number which would be assigned to the book in accordance with the Library of Congress classification (*B*); and (3) the order number by which the card is obtained from the Library of Congress (*C*).

016.54
M 48

Mellon, Melvin Guy, 1893–

Chemical publications, their nature and use, by Melvin Guy Mellon ... 1st ed. New York [etc.] McGraw-Hill book company, inc., 1928.

viii, 253 p. incl. illus., forms. 21cm. (*Half-title:* International chemical series)

1 {1. Chemistry—Bibl. 2. Chemistry—Study and teaching. 3. Bibliography—Best books—Chemistry. I. Title.

28—25168

	B	*C*
Library of Congress	Z5521.M52	
——— ——— Copy 2.		
Copyright A 175	[38v2]	

In contrast to the foregoing scheme, another system consists in maintaining three card files, as follows:

1. Author catalogue—arranged alphabetically, containing names of all authors and societies; also titles of all periodicals, of anonymous works, and of important sets or series of works.

2. Classified catalogue—based on the Dewey, or other, system already described. The arrangement of the cards in the

[1] In addition to preparing such printed cards for every book receiving a United States copyright, the Card Division of the Library of Congress is prepared to sell collections of cards for special fields.

classified catalogue corresponds to the actual arrangement of the publications on the shelves.

3. Index to the classified catalogue—arranged alphabetically. To find all the works on a given subject, one consults this index under the name of the subject. The number at the right-hand corner of the card gives the class number under which the works desired may be found in the classified catalogue. For example, if one is interested in electric lighting, the following will be found in the index:

Electric lighting	621.32
Illumination, electric	621.32
Lighting, electric	621.32

The subject is thus fully indexed, and by consulting the classified catalogue under the number 621.32 all works on the subject of electric lighting will be found.

A subject index similar to the one just mentioned has been devised on a decimal system by the U. S. Office of Experiment Stations for the articles in the reports and bulletins issued by the agricultural experiment stations of the various states.[1] In using this index, it is necessary to locate the desired number for the subject in the key to the index and then turn to the cards with this number. Works on analytical chemistry, for example, bear the number 1.26, 1 being for general science, 0.2 for chemistry, and 0.06 for analytical chemistry.

Working in a Library.—Although a knowledge of the actual layout of the library in which one is to work is of value in making efficient use of one's time, no general statement can be made covering what will be found in all libraries, since there is more or less variation in practice.

Usually in a general library there will be one or more reading or reference rooms, depending upon the size of the library, in which are shelved the reference works, periodicals and other publications most often used. Current numbers of periodicals may be segregated in a separate periodical reading room. If the library is of sufficient size, there seems to be a commendable tendency to make several major divisions of it, in which case the library's chemical publications probably will be found in a

[1] *Circ.* 37, U. S. States Relations Service.

technological division having its own reading room and library equipment. But whether the library is of a general or specialized nature, the usual practice of librarians, in caring for the publications not found in the reading and reference rooms, is to shelve them in the portion of the building known as the stacks.

In shelving publications, librarians may differ in making certain special arrangements, even though they use the same system of classification, such as the collection in one place of special types of publications, dissertations, governmental bulletins, and odd sizes of books, for example, regardless of the nature of the subject matter in them.

Although one may obtain a given publication with certainty by looking up its call number in the card catalogue and presenting this to a competent member of the library staff, it is frequently much more advantageous, especially if a considerable number of publications must be consulted, to familiarize one's self with the layout, the system of classification, and the rules of the library, and then to obtain permission to go directly to the stacks to use the various works there. In working in a periodical set, for example, one frequently wants to refer to various volumes of the set which were not indicated in connection with the first reference sought.

Locating Desired Information

Having acquainted one's self with the different kinds of chemical publications, with the manner of arranging them in a library, and with the means afforded for finding them, our interest is now directed to the question of what constitutes a reliable and efficient method of ascertaining the specific information available upon a given subject. We must not only be able to find the proper books, bulletins, and other works, but also to find specific facts which they contain, or to assure ourselves that desired facts are unavailable.

The proper procedure to follow is more or less dependent upon the nature of the information desired. As Barrows stated,[1]

> Searches or investigations of the chemical literature . . . may be made from various standpoints—for example, by the research chemist, to familiarize himself with the available published information along

[1] *Chem. Met. Eng.*, **24**, 517 (1921).

the lines of his research; by the student, as a part of his studies or research; by the writer or author who, in his articles or publications, desires to give credit to the work of others, or to review the prior literature along the lines of his own publication; by the bibliographer, as the basis of his bibliography; by the manufacturer, to obtain information of interest along the lines of his manufacture or along new lines of development; by the patent investigator, in connection with questions relating to the novelty and patentability of inventions, and the validity and infringement of patents.

The volume of material which has to be consulted will vary widely, depending on the object the searcher has in view. If he wants to know the solubility of sodium chloride in water under ordinary conditions, for example, it is sufficient merely to turn to Olsen's "Chemical Annual" for the data. If knowledge of the details of the procedure employed by the investigator in determining these data is required, larger works of reference must be consulted where the original reference is given, including a statement of its place of publication. Again, if a complete summary is required covering all the work that has been done on this determination, one must make a much more extended search of all portions of the chemical literature likely to contain such facts.

It is obvious that one entirely unfamiliar with the chemical literature might experience much difficulty in finding even the solubility of sodium chloride in water.[1] He would lack the general knowledge or perspective which provides one with a sense of direction regarding the proper course to follow. This sense of direction, acquired only by more or less experience with the literature, is of immense value in locating facts. Without it, one is greatly handicapped; with it, not only much time is saved, but also the thing desired is much more likely to be found. It is a common experience to have senior students, when given a subject to look up in *Chemical Abstracts*, return shortly with the statement that they looked all around but could find little or nothing on their subject.

[1] The student should not forget that, even though certain facts cannot be found in published works, he ordinarily has two other possible methods of obtaining the desired information: he may inquire of the individual who knows what is desired, or he may resort to experiments in the effort to determine the facts for himself.

Given this sense of direction, or perspective, in handling chemical literature, able searchers will know where to look for certain kinds of information. Journals of physical chemistry will not contain papers on the synthesis of new organic compounds; details for the quantitative determination of lead will be found in works on analytical rather than inorganic chemistry; and commercial statistics relating to the chemical industry are to be found in industrial and trade journals and government publications rather than review serials. Such knowledge helps. But the sense of direction is probably of most value in connection with the use of indexes, such as those of reference works, card catalogues, and abstracting journals. So important is this point that the indexing portion of chemical publications deserves special consideration.

INDEXES

In general, an index may be considered as a device which indicates the existence, location, or means of finding definite information. In an ordinary book, for example, the index differs from the table of contents in that the latter indicates, more or less in detail, the main divisions of the material in the order in which they are treated, while the former indicates, in alphabetical order, each significant item in the text. Since indexes of publications should be adequate directories for the purpose intended, it is of the first importance to know something about the nature and use of these facilities for locating information.

Dr. E. J. Crane, the present editor of *Chemical Abstracts*, has presented a valuable discussion of this subject from the viewpoint of one who has had long experience in both making and using certain kinds of indexes. The quoted paragraphs in the following portion of this chapter are taken from his paper.[1]

> The main problem, of course, in using the journal literature is in finding references, all that are pertinent to the subject in hand, in order that one may learn what the literature contains and all that it contains relating to this subject. This is often difficult. It is doubtful if there is a more important problem for students, in college or out, to learn how to solve. Its solution involves to some extent a familiarity with the more important journals, particularly the abstract journals;

[1] *d. Eng. Chem.*, **14**, 901 (1922).

but above all it involves a knowledge of indexes and how to use them. References to the journal literature are often obtained from books or from one paper to others, but mostly they are obtained from indexes, usually of abstract journals. It is frequently assumed that the use of indexes in making literature searches is a simple matter requiring no special experience or ability. This is a mistake. The making of indexes is an art in itself, involving more than a comprehensive knowledge of the general subject being covered, and the use of indexes is not less an art. This deserves emphasis. It is true, because existing indexes vary greatly in kind, thoroughness, and quality. Even in the use of the best subject indexes the user must meet the indexer part way for good results. Conscious effort to become a good index user will well repay any scientist. Many a day has been spent in the laboratory seeking information by experiment which might have been obtained in a few minutes, or hours at the most, in the library, had the literature search been efficient.

What constitutes a good index? The test is to determine whether or not an index will serve as a reliable means for the location, with a minimum of effort, of every bit of information in the source covered which, according to the indexing basis, that source contains. To meet this test an index must be accurate, complete, sufficiently precise in the information supplied, and so planned and arranged as to be convenient to use. Existing indexes fall far short of this ideal in many cases, and of course somewhat short of it in all cases.

The main purpose in indexing is partially lost sight of through an effort to bring some sort of classification into it. Classification in connection with indexing frequently detracts from, rather than enhances, the efficiency and usefulness of an index, and is beside the main purpose.

Scope.—Indexes vary widely in the extent of the material indexed, ranging from a small number of entries in the back of a small book to sets of several large volumes. Each individual reference book, bulletin, or monograph will ordinarily contain its own index. In the case of a set of reference works, consisting of a number of volumes, each volume may or may not have its own index. If not, and occasionally even if they do, there will be a general index to the whole set. For periodicals, it is the usual practice to have an annual index in the final volume of the year, in case there are two or more. In addition, many periodicals have been provided with cumulative or collective indexes covering a period of years, frequently five, ten, or more. These are very desirable for making searches, as in the case of

the decennial indexes of *Chemical Abstracts*. They not only save time but also provide the indexer with an opportunity for correcting and improving the material taken from the annual indexes to make up the cumulative work. Indexes to patents may be annual or cumulative. It has already been mentioned that the index serials are annual publications.

Types.—Depending chiefly on the nature of the information to be indexed, one finds in more or less common use at least the four following bases of indexing:

1. *By Patent Number.*—This type is considered in the chapter dealing with the literature on patents. In the majority of cases one would not have to rely on patent number indexes only, since other information, such as title of the patent or the patentee's name, would be available for searching in the other types of indexes.

2. *By Formula.*—Two variations of formula index are in use: one consists of empirical formulas and serves for all types of compounds; the other consists of ring formulas for complex organic compounds. This type may be used for any chemical compound whose empirical or ring formula is known. It avoids introducing the uncertainty of name which may exist for some compounds, particularly those with the more complicated structures. The different formula indexes in use are discussed in Chap. VIII.

3. *By Author.*—In practically every printed article relating to chemistry, whether abstract, book, bulletin, periodical, or patent, the name of the author (or patentee) is mentioned. Also in treatises frequent mention is made of the names of investigators in connection with results or conclusions given in reports of their investigations. Whenever the number of these names becomes fairly large and it is of importance to be able to find readily the mention made of them, separate author indexes are often issued. This practice is more or less general for periodicals.

The arrangement used is alphabetical, although some variation is found in handling cases like names beginning with *M'* or *Mc*. In such instances, before giving up a search, one should look in all possible places where the entry might occur.

Some other sources of confusion in this type of index are the following: names in languages using non-Roman characters;

names with several parts; and names differently spelled but similarly pronounced.[1]

4. *By Subject.*—Although at times patent number and author indexes, and particularly formula indexes, are very useful, their general value is not comparable to that of an index of subjects alphabetically arranged. Subject indexes are not only the most generally useful type, but they are, undoubtedly for this reason, the most common.

It is comparatively easy to make a complete index of the other types, but a complete subject index is an ideal much more difficult to attain. Those available vary widely in this respect, a state of affairs for which the maker is primarily responsible.

The Use of Indexes.—Our chief problem in connection with indexes, after learning the types available, where they are likely to be found, and the kind of information they contain, is to learn how to use them. For indexes of patent numbers and of authors the procedure is obvious; for formula indexes this matter was presented in connection with the discussion of reference works (see Chap. VIII). But subject indexes, owing to their nature, require special attention. The following discussion on this point is from the previously mentioned paper of E. J. Crane.

The first step in learning how to use subject indexes with maximum effectiveness is to become familiar with the characteristics and peculiarities of existing chemical indexes.[2] The most significant point to note is whether or not a so-called subject index is really an index of subjects or an index of words. The tendency to index words instead of thoroughly to enter subjects constitutes the greatest weakness in the literature of chemistry. There is a vast difference. Words are of course necessary in the make-up of a subject index, but it is important for an indexer to remember that the words used in the text of a publication are not necessarily the words suitable for index headings or even modifying phrases. Word indexing leads to omissions, scattering, and unnecessary entries. After the most suitable word or group of words from the indexing point of view has been chosen for a heading, it should of course be used consistently no matter what the wording of the text

[1] See introduction to author section of third decennial index of *Chemical Abstracts.*

[2] For example, the key or explanatory matter given in connection with both the author and subject indexes of the third decennial index of *Chemical Abstracts.*

may be. To illustrate a kind of scattering of entries which may result from word indexing, let us consider such a series of article titles as follows: "An apparatus for the determination of carbon dioxide"; "A new absorption apparatus"; "Apparatus for use in the analysis of baking powder"; "An improved potash bulb"; and "Flue-gas analysis." Word indexes would no doubt contain an entry under the heading "Carbon dioxide" for the first title, one under "Absorption apparatus" for the second, under "Baking powder" for the third, under "Potash bulb" for the fourth, and under "Flue gas" for the fifth, and probably no others. These entries seem reasonable enough if the titles are considered separately without thought of the others. And yet the articles may all be descriptive of the same sort of apparatus. As a matter of fact, all these titles might conceivably be used for the same article; if the author happened to be working on baking powder or on flue-gas analysis when he conceived the idea for his novel piece of apparatus, or had it in mind particularly for one purpose or the other, he might choose one of the more specific titles for his article rather than one of the more general ones.

In an index entirely based on subjects rather than words, it would be the task of the indexer to see that all these articles got indexed under one heading, or under each of more than one heading, best with cross references pointing from the other possible headings to the one or more headings used. Or, if there seems to be some justification for scattering owing to differences in point of view (word indexing cannot be gotten away from entirely), he would make sure that the necessary cross references are supplied to lead the index user about from heading to heading so that all entries can be readily located. It is not hard to determine whether or not an index is a word index; when this is suspected or noted, one should look around pretty thoroughly in its use instead of being satisfied that the entries found under the obvious heading are all that the index contains on a subject.

It is important to note the approximate degree of completeness of an index in use. There is perhaps no definite point at which a subject index may be said to be complete. The indexing basis is too indefinite. A great many subject indexes are not as full as they ought to be. Aside from word indexing the indexing merely of titles is the most common reason for incompleteness. Titles cannot be depended upon to furnish the information necessary for adequate subject indexing. An index may be reasonably complete from one point of view and not from others. For example, a publication devoted to bacteriology may not reasonably be expected to be indexed fully from the chemical point of view. Completeness in the information supplied in modifying phrases, as well as completeness in index headings, needs to be taken

into consideration. It is necessary, of course, to call forth one's resourcefulness to a special degree if a relatively incomplete index is to be used.

Cross references play an important role in subject indexing and in the use of subject indexes. Word indexing is really hard to avoid and cross references are the great preventive. It is a good sign if a subject index has a plentiful supply of cross references, both of the "See" kind and the "See also" kind.[1] They make for uniformity and proper correlation. "See also" cross references are of just as much importance as the "See" kind, though not as much used. The service which they render in directing the index user to related headings or to headings which, though dissimilar for the most part, have entries under them likely to be of interest to the investigator who refers to the original heading, is often the chief means of making a search complete. It is not reasonable to expect an index user, or an indexer, as a matter of fact, to think of all the headings representing related or significant subjects under which headings he may find valuable references that otherwise might be missed. Nevertheless, in the careful indexing, year after year, of a periodical devoted to a more or less definite field, as an abstract journal for example, subjects are met in such a variety of connections and from so many angles that it is possible for a truly comprehensive list of cross references to be built up. The suitability of a given "See also" cross reference may not be clear, much less suggest itself, until a specific case in which it is helpful is observed. It often pays to follow up such a cross reference even when it does not look as if it applies in a given case. The indexer, in surveying the whole field year after year, is in a position to make valuable suggestions in the form of cross references calculated to lead the index user from place to place in the index, so that the chances that his search will be really exhaustive as far as that particular index is concerned are much increased.

Persistence is a good qualification for index searching. It is desirable to avoid being too soon satisfied. There is no task in which thoroughness is more important. It involves first a knowledge of the index system and of the characteristics of the index. Then one needs to be resourceful, exhausting all possibilities, if he is to avoid some futile searches or incomplete findings. One's fund of general knowledge can usually be brought into service to good advantage.

[1] Cross references which refer from a possible heading under which no page references are given to the chosen heading where they may be found are called "See" references, as "Mineral oils. See Petroleum"; those which connect headings representing allied subjects or containing related entries are called "See also" references, as "Iron alloys. See also Steel."

On account of the necessity of drawing on one's general knowledge in making a literature search in any field, it is in many instances important that one should make his own searches. It is not always safe to let someone less informed in a certain field make an index search when a complete survey is desired, even though his familiarity with indexes and the literature in general may be better than one's own. Just as some tasks in the laboratory can be turned over to another to advantage, but not the more important determinations and experiments, so some tasks in the library can be delegated to an assistant, but not all such tasks. Knowledge, skill, and power of observation are factors fruitful of important results in the library as well as in the laboratory. Literature searching is a dignified pursuit, and it cannot with impunity be assigned to a lower level than that of the laboratory side of the problem, as far as the attention it receives is concerned.

With a given problem at hand the first step, of course, is to think out the most likely places to look in the indexes to be used. This may be a simple matter or it may be a very difficult one, depending on the nature of the problem. Difficulty increases with indefiniteness. Experience is necessary. In fact the beginner is often completely at a loss to know what to do at this very first stage of his search. This point is stressed in the Report of the Subcommittee on "Research in Chemical Laboratories" presented to the Committee of One Hundred on Scientific Research in December, 1916.[1] In this report, which commends and recommends courses in chemical literature searching in the universities, it is pointed out that the average graduate "fails to analyze the subject" in which he is interested "into its factors, and, hence, generally looks for topics which are too general. Because he does not find any references to the problem as a whole as he has it in mind, he assumes that nothing has been done upon it and that there is nothing in the literature which will be of aid to him in the investigation. Were he to separate his subject into its essential parts and then to consult the literature on each factor, he would find considerable information which he otherwise would miss." Even though some index headings to which to turn, perhaps the more important ones, may be brought to mind without ingenuity, the completeness of a search may be marred by a failure properly to analyze the problem. Indexes with cross references, particularly "See also" ones, help.

Too much dependence on cross references is not advisable. They may not be available at all and they are never complete. With a given heading in mind it is well to cudgel one's brain for synonymous words or phrases to try, as well as for variously related subjects, and

[1] *Science*, **45**, 34 (1917).

of alkali metal halides in general may be of just as much interest and value to the search in hand as one specified to be particularly for sodium chloride, and yet the indexes are not likely to carry entries for each of the members of a group of compounds if a definite group is under discussion. Cross references may be supplied in some cases but it is hardly reasonable to expect an index to go further. A process for electrolyzing chlorides, for instance, could not within reason be entered under headings representing each of the numerous known chlorides. The index user must expect to think of such possibilities and make his search complete accordingly. Another different kind of lead to follow to insure a complete search, particularly when the indexes to be used are word indexes, is to think of the products of the process being studied, in this case, chlorine, sodium hydroxide, and possibly sodium hypochlorite. And in addition to looking up the headings represented by the names of these compounds, completeness is insured only by trying the headings "Halogens," "Alkalies" or "Alkali metal hydroxides," and again possibly "Alkali metal hypohalites" and "Hypohalites." The product of some simple electrolytic process which does not involve the recovery of chloride or alkali may be merely called "Bleaching solution" or be given some like name. And still further it may be worth while to look up such a heading as "Potassium chloride" as a representative of a closely related compound which might be subjected to a similar process, or at least might be studied as to the possibilities. Still other headings worthy to be tried are "Electrolytic cells" and possibly "Electrolysis"; this last heading, however, is too general to be used as an index heading for every process involving electrolysis, and is not likely to be used for studies or discussions of specific resourcefulness and the use of one's general knowledge of chemistry must come prominently into play in the making of index searches.

The resourcefulness necessary in the location of information by means of the great variety of subject indexes in existence may seem to be little more than clever guessing at times. A paper on glass, so-called and indexed only under "Glass," may reveal a principle governing the action of metals or other undercooled melts. Authors fail to see the full significance of their experimental results, and it is not often that the indexer will go further than the author in bringing out this significance for attention. The kind of flexible ingenuity necessary for the location of information in this way is perhaps only to be acquired by experience. It is really more than guessing that results in the location of information in this way, and yet it seems as if a little more than reasoning power, something like intuition, is sometimes necessary.

Chemical publications present a special problem, both to the subject indexer and to the index user, in that many headings must consist of the names of chemical compounds. The difficulties encountered are to be attributed (1) to the fact that many compounds have, or may have, more than one name, (2) the names, or at least the best names, of the more complex compounds may be difficult to ascertain, and (3) new compounds are constantly being prepared, which, if named at all, may receive more than one name which is justified from one point of view or another, and the possibilities of incorrect names are great.

It is not feasible to enter into a detailed discussion of the best procedure in building or using indexes of chemical compounds. The difficulties increase with increasing complexity of compounds. Some indexes are based on systematic nomenclature, irrespective of names used by authors; others are not. Cross references within an index and introductions thereto, and the use by index searchers of dictionaries, chemical encyclopedias, handbooks, and other sources of information, leading to a knowledge of the names, sometimes numerous, of compounds, are helps to be utilized. As mentioned above, a knowledge of what constitutes good nomenclature is a great aid in the location of compounds in name indexes. This is particularly important for the organic chemist. It is on account of the almost insurmountable difficulties due to the complexities of chemical nomenclature and because of language differences, that a basis other than their names—namely, their empirical formulas—has been sought and, to a limited extent, used, in the indexing of compounds. A formula index provides a certain means for the location of individual compounds; it is very doubtful if the average chemist can locate compounds in all cases in name indexes even though systematic nomenclature may have been consistently followed in the indexing. In name indexes it is possible, by appropriate devices, to group related compounds to good advantage.[1]

The subject index searcher is confronted with nomenclature problems relating to fields other than that of chemical compounds. For example, the chemist interested in plants must contend with the fact that some indexes use the scientific names (genus and species) of plants as headings and others use common names, of which there are frequently several for the same plant.

The use of indexes in foreign languages presents obvious difficulties. It is one thing to be able to read a foreign language and another to translate one's thoughts into that language. The use of an English-French, English-German, or other like dictionary, depending on the

[1] PATTERSON, *Ind. Eng. Chem.*, **11**, 989 (1919).

language involved, is about the only help available. The introduction to Patterson's "German-English Dictionary for Chemists" and that to his "French-English Dictionary" contain some helpful suggestions useful for determining German and French names of chemical compounds.[1]

Locating Names of Compounds.—The attainment of an efficient working knowledge of chemical nomenclature, as mentioned above, is a task which in itself is of no small proportions. Yet if one should try to locate in an index the more complex compounds, now comparatively common, especially in organic chemistry, without an idea of the system used in naming them, he would be almost hopelessly lost.

Unfortunately, chemists have not yet agreed upon an international basis of nomenclature, although encouraging progress in that direction has been made.[2] But even if that highly desirable goal were now achieved and everyone used the system, we would have, preceding the time of its realization, 150 years' literature of modern chemistry more or less confused in this respect. This almost necessitates one's learning more or less about each subject index to be used.

For the purposes of this work, only the practice followed in *Chemical Abstracts* will be considered, since this periodical's present indexing probably represents the best there is. The procedure now followed in it reached the present stage only after years of study of the problems involved.[3] The following material in fine print represents excerpts from (1) the section on nomenclature in a publication issued in connection with *Chemical Abstracts* under the title, "Directions for Assistant

[1] The following dictionaries may be helpful: BOSCH, "Nederlandsch-Engelsch-Fransch-Duitsch technisch Woordenboek"; MAYER, "Chemisches Fachwörterbuch"; THUROW, "Wörterbuch der Chemie"; and DEVRIES, "German-English Science Dictionary."

[2] For an unofficial report by A. M. Patterson of a meeting of the International Nomenclature Committee, see *Ind. Eng. Chem.*, **18**, 320 (1926).

[3] PATTERSON and CURRAN, *J. Am. Chem. Soc.*, **39**, 1623 (1917), a system of organic nomenclature; PATTERSON, *Ind. Eng. Chem.*, **11**, 989 (1919), the decennial index (of *Chem. Abs.*) as an aid to organic research; PATTERSON, *J. Am. Chem. Soc.*, **47**, 543 (1925), proposed international rules for numbering organic ring systems; *ibid.*, **50**, 3074 (1928), the nomenclature of parent ring systems; *ibid.*, **55**, 3905 (1933), definitive report of the commission on the reform of the nomenclature of organic chemistry.

Editors and Abstractors of Chemical Abstracts," and (2) the subject index of this periodical for 1938. The first consists of points of advice to those having the problem of naming compounds to appear in the index; while the second is a statement of general principles to be kept in mind as an aid in finding names of compounds in the index.

To Index Makers.—Names used for compounds in the original articles should in general be retained, with such alterations as are needed to make them conform to the following express rules. However, abstractors are at liberty to make further changes if author's names seem unsatisfactory.

The naming, by abstractors, of compounds not named in the original, or any renaming of compounds beyond bringing them into conformity with the rules which follow, should be in accordance with the principles of the system of nomenclature used in the Decennial Index (see references mentioned above).

If the name selected by the abstractor for a compound differs very greatly from that selected by the author, the latter name should be given and should be followed by the former in brackets.

In naming a compound so as to indicate that oxygen is replaced by sulfur the prefix *thio* and not *sulfo* should be used (*sulfo* denotes the group SO_3H); thus, HSCN, *thio*cyanic acid; H_3AsS_4, *thio*arsenic acid; $CS(NH_2)_2$, *thio*urea; $Na_2S_2O_3$, sodium *thio*sulfate. The only use of *thio* as a name for sulfur replacing hydrogen is in cases in which the sulfur serves as a link in compounds not suitably named as mercapto derivatives; thus $H_2NC_6H_4SC_6H_4NH_2$, *thio*bisaniline. *Thia, oxa,* and *aza* are used when sulfur, oxygen, or nitrogen, respectively, replaces carbon (or CH or CH_2), *e.g.*, *thia*carbocyanine, *oxa*diazole. *Hyposulfurous acid,* not hydrosulfurous acid, should be used to designate $H_2S_2O_4$.

The word *hydroxide* should be used for a compound with OH and *hydrate* for a compound with H_2O. Thus, barium *hydroxide*, $Ba(OH)_2$; chlorine *hydrate*, $Cl_2.10H_2O$.

Salts of chloroplatinic acid are *chloroplatinates* (not platinichlorides). Similarly, salts of chloroauric acid are to be called *chloroaurates*, and of fluoboric acid, *fluoborates*.

Hydroxyl derivatives of hydrocarbons are to be given names ending in *-ol*, as glyce*rol*, resorcin*ol*, pinac*ol* (not pinacone), mannit*ol* (not mannite), pyrocatech*ol* (not pyrocatechin).

Compounds which are not alcohols but have received names ending in *-ol* should be spelled *-ole*, as anisole, indole. The final "e" of the *-ole* ending should be retained in all combinations. Note that C_6H_6 is preferably called benzene (not benzol), C_7H_8 toluene, etc. Benzene rather than benzol or benzole is also preferred for the mixture of hydrocarbons of the benzene series obtained in the refinement of coal tar. 2-Furaldehyde (or less desirably furfural) is preferred to furfurol or furfurole to indicate that the compound is an aldehyde.

As between the endings *-in* and *-ine*, the latter should always be used for *basic* substances, and for them only; *-in* is used for glycerides, glucosides, bitter principles, proteins, etc. Thus anil*ine*, tyros*ine*, pur*ine*, morph*ine;* but gelat*in* (not gelatine, nor glutine), palmit*in*, amygdal*in*, albumi*n*, prot*ein* (not proteid). In translating, it should be borne in mind that for both basic and neutral substances the Germans use *-in* and the French *-ine*. It is to be noted that this rule does not apply to substances which are not considered to be definite compounds, as *gasoline.*

German words ending in *-an* should be translated *-ane* if they are names of hydrocarbons (or parent compounds of the heterocyclic series) which are fully saturated; otherwise *-an;* as meth*ane*, menth*ane*, diox*ane* (but benzodiox*an*, because one ring is unsaturated), fur*an*, pentos*an*.

German names ending in *-it* should be translated *-ite* rather than *-it;* as permut*ite*. If it seems desirable to retain the original form of a trade name its initial letter should be capitalized. Alcohols such as $C_6H_8(OH)_6$ (German Dulcit) are exceptions.

German names of acids should generally be translated by substituting *-ic acid* for "säure." Some well-established names are exceptions, as Zuckersäure (saccharic acid), Milchsäure (lactic acid), etc. For a few well-established names it is correct to translate "-insäure" as *-ic acid* instead of *-inic acid, e.g.*, acridinsäure is acridic acid. Names ending in "-carbonsäure" are to be translated -carboxylic acid (not -carbonic acid), but -carbonyl chloride is preferred to -carboxylyl chloride.

The names of radicals as given in the "Introduction to the Decennial Subject Index" should be preferred.

In naming organic compounds the connective *o* is to be used invariably in such names of substituent radicals as amino-, bromo-, chloro-, cyano-, and iodo-; thus, bromobenzene, chloroacetic, nitroaniline. This conforms to the demands of euphony and also makes for uniformity in indexing. There are a few apparent exceptions to this rule, as cyanamide, nitramino-. Benzo-, naphtho- (not benz-, naphth-) are to be used before consonants.

Acid radicals, such as C_6H_5CO-, must have names ending in *-yl* and their compounds with halogens, as C_6H_5COCl, are to be termed chlorides, bromides, etc. Thus, acet*yl* chloride (not chloride of acetic acid or acetic acid chloride) and cinnam*oyl* bromide.

The names of the groups NH_2, NHR, NR_2, NH or NR should end in *-ido* only when they are substituents in an acid group, otherwise in *-ino;* thus, MeC(:NH)OEt, ethyl im*ido*acetate; $NH_2CH_2CH_2CO_2H$, β-am*ino*propionic acid (not amidopropionic acid); $NHPhCH_2CH_2CO_2H$, β-anil*ino*propionic acid; $CH_3C(:NH)CO_2H$, α-im*ino*propionic acid.

Hydroxy-, and not *oxy-*, should be used in designating the hydroxyl group; as *hydroxy*acetic acid, $CH_2(OH)CO_2H$, not *oxy*acetic acid. *Oxo-* is to be preferred to *oxy-* to designate oxygen in the group -CO-.

For complex radicals, parentheses and brackets should be freely used in order clearly to fix the relation of modifying substituents. For example, $ClCH_2CH(COOH)_2$ should be written (chloromethyl) malonic acid, not chloromethylmalonic acid, for the latter names $CH_3CCl(COOH)_2$.

The term *ether* is to be used in the usual modern acceptation only, and not as an equivalent of *ester*. Esters and metallic salts should be designated in the form, diethyl phthalate, methyl hydrogen succinate, sodium propionate, etc.; and *not* as the diethyl ester of phthalic acid, succinic acid monomethyl ester, or the sodium salt of propionic acid.

Ethers of hydroxy compounds should not be named as O-derivatives where a better name is possible; thus, *α-ethoxy*propionic acid, $MeCH(OEt)CO_2H$ (not ethyllactic acid, or lactic acid ethyl ether).

In the naming of cyclic compounds reference to the ring index in the Decennial Indexes will be found helpful.

The names *butane, pentane, butyl, propyl*, etc., should be used only for the normal hydrocarbons and normal hydrocarbon radicals and, with the prefix *cyclo-*, for saturated cyclic hydrocarbons and their radicals. Geneva names for aliphatic hydrocarbons, alcohols, acids, aldehydes and ketones may be used.

The names *ethylene* and *acetylene* have the preference over ethene and ethyne. The names of acetylene or triple-bond hydrocarbons should end in *-yne* instead of *-ine*.

Salts of organic bases with hydrochloric acid should be called *hydrochlorides* (not hydrochlorates or chlorohydrates). Similarly, hydrobromide, hydroiodide, methiodide (not iodomethylate), methochloride and methosulfate should be used.

The system of numbering organic compounds used in the annual indexes to *Chemical Abstracts* starting with that of Vol. 31 is preferred; if the author's numbering is given, any departure from this system should be clearly indicated.

Position numbers should precede, not follow, the part of the name to which they refer, as 2-bromo-3-methylbenzenesulfonic acid.

To Index Users.—Simple inorganic compounds are entered under the usual names. With the exception of a few common compounds, such as carbon dioxide and carbon monoxide, compounds of a given element with another or with a definite radical, which differ only in valence relations, are grouped together. For example, the various oxides of nitrogen are grouped under the heading *Nitrogen oxides* and classified there, bold-faced formulas being used as subheadings, and for compounds of iron, gold, copper, and tin such headings as *Iron sulfates*, under which the "ous" and "ic" salts are entered, are used rather than headings beginning with "ferric (ous)," etc.

Acidic salts and many basic salts have been grouped under the simple names for the neutral or normal salts, *e.g.*, *Calcium phosphates*, also with the use of bold-faced formulas as subheadings. In certain cases, basic salts are entered under names such as *Bismuth oxynitrate*.

In many instances acids and salts have been grouped under such headings as *Silicic acids* with the avoidance of headings with prefixes such as meso-, meta-, ortho-, para-, pyro-, di-, tri- and poly-.

For binary compounds and mixed halides the order of decreasing electropositivity for nonmetallic elements has been followed: Sb, As, B, Si, C, P,

Te, Se, S, I, Br, Cl, N, O, F, except that the headings *Fluorine oxides, Nitrogen chloride, Nitrogen iodide*, etc., are used.

For the most part binary compounds of hydrogen are indexed under the names most commonly used, *e.g., Arsine* and *Hydrogen sulfide*.

Complex inorganic compounds which can not be given definite names satisfactory for index entries are usually indexed under the heading which represents the class of compounds concerned and under a heading based on the name of the significant element. Ammino compounds are treated in this manner. In addition to the significant-element entry an entry is made at *Ammino compounds* or in some cases at the heading for the specific organic base that may play the same role as NH_3. For example, dichlorotetramminecobaltic chloride would be indexed under *Ammino compounds* and under *Cobalt compounds*, and $[C_{15}H_{11}N_3.AgNO_3]NO_3$ under *Pyridine, 2,6-di-2-pyridyl-* and *Silver compounds*. The headings *Acetato compounds* and *Oxalato compounds* are used for specific compounds, but similar special treatment is not extended to other acidic radicals grouped around the central coordinating elements. For many compounds of intermediate complexity with names that might be considered suitable for index entries but that are not generally recognized, two or more entries are made, as under such a general heading as *Chromium compounds* and under the specific acid or salt name used by the author or selected as suitable. For example, entries would be made at both *Chromium compounds* and *Ammonium fluochromite* for $(NH_4)_3CrF_6$; at *Germanium compounds, Tungsten compounds*, and *Cesium tungstigermanate* for $Cs_3[Ge(W_3O_{10})_4].5H_2O$; and at *Copper compounds, Tartaric acid*, and *Sodium cuprotartrate* for $NaCuC_4H_4O_6.2H_2O$. For complexes of the better known types such as chloroplatinates, and fluoberyllates, entries are made only at the names of the specific compounds.

For organic compounds only the general principles are given here, but in the index itself will be found abundant cross references and also notes under *Alcohols, Ketones*, etc., indicating how compounds of these classes are named.

The "chief function" of a compound is expressed *in the main part of the name* wherever possible, and not as a substituent, thus: pyrrolecarboxylic acid not carboxypyrrole; ethyl alcohol or ethanol, not hydroxyethane; pentanone, not oxopentane.

In compounds of mixed function, the chief function is determined from the following order of precedence: *"onium" compounds, acid* (carboxylic first), *acid halide, amide, imide, aldehyde, nitrile, ketone, alcohol, phenol, thiol, amine, imine, ether, sulfide* (and *sulfoxide* and *sulfone*). Thus, hydroxybenzonitrile, not cyanophenol; aminophenol, not hydroxyaniline.

A multiple chief function is expressed where feasible as -idol, -dicarboxylic acid, etc., rather than as hydroxy -ol, carboxy -acid, etc. But amino and imino groups attached to cyclic bases are treated as substituents; as, aminopyridine.

The index compound should be as large, and the substituents as small, as is practicable in conformity with the foregoing rules, as ethylbenzene, not phenylethane. But such names as diphenylethane and triphenylmethanol are exceptions. When the chief function is in a side chain attached to a com-

plex nucleus, "additive" names are preferred in order to harmonize the preceding; thus, naphthaleneacetic acid, not naphthylacetic acid (with the result that the compound is indexed with other naphthalene derivatives instead of under acetic acid).

The main part of the name with its functional ending, if any, is placed first in the index, the names of substituents following; thus, chloroacetic acid would appear in the index as *Acetic acid, chloro-* and dihydroxyanthraquinone as *Anthraquinone, dihydroxy-*. The part thus placed first is called the "index compound"; it may or may not be the "parent compound" (in the second example the parent compound is anthracene).

Names in which two functions are expressed in the index compound, as propanolene, cyclopentanonecarboxylic acid, are avoided, except that a few very common ones, such as phenolsulfonic acid, are used (indicated by cross references).

The names of the substituent radicals in the name of a compound are arranged *in alphabetical order;* as benzylethylmethylphenyl-ammonium chloride. The number of radicals of each kind does not affect the order (*e.g., benzyl* precedes *ethyl* no matter how many of each are present); but the compound name of a substituted radical is treated as a unit with its own alphabetic position; thus *dimethylamino*, Me_2N-, follows *benzyl* but precedes *ethyl*. When the complete name has been formed, it is alphabeted like any other word.

Parentheses, brackets, and even braces are used where necessary to mark off radical names.

Arabic numerals are given preference for numbering, although Greek letters are used in accordance with common practice with "trivial" names of aliphatic acids, aldehydes, etc., and for some side chains. The numbering of each parent ring system is shown by ring formulas in the index under its name.

When two or more numberings are equally indicated, that one is chosen which gives the smallest number or numbers for the *chief function, then for double bonds* if these must be regarded, *then for triple bonds, then for point of attachment* (doubled molecules), *then for substituents.*

Numbers and letters enclosed in brackets within the name of a parent ring system are used for distinguishing isomers.

Numbers in parentheses are used to indicate the position of entering hydrogen necessary to the existence of the compound; thus, 4(3)-quinolone is equivalent to 3, 4-dihydro-4-oxoquinoline.

Doubled molecules or radicals are indicated by names commencing with *bi-* (as, *o,o'*-biphenol, biphenyl, $\Delta^{4,4'}$-bipiperidine). *Bis-*, *tris-*, etc., are used before complex expressions; as, bis(dimethylamino)-.

In using the *cross references*, the *general* nature of many of them should be kept in mind; thus, the reference, "*Benzene, ethoxy-. See Phenetole*" is applicable not only to this compound itself but to derivatives, which are indexed under it rather than under *Benzene*.

For all compounds of known formula, the Formula index should be consulted.

Making Searches[1,2,3]

With these points in mind concerning indexes, we may consider briefly certain procedures to follow in locating given kinds of information. The procedure suggested is not to be taken as covering all kinds of searches, but rather as indicating a satisfactory scheme for the cases mentioned. Neither should it be considered as the only way to proceed to find the information desired. Different individuals will attack a given type of problem differently, and the same individual may attack different types of problems differently.

From the standpoint of the literature involved, searches (disregarding patents, which were discussed in Chap. IV) will usually be one of two general kinds: those in which specific facts are to be located, which can be found more or less easily in handbooks or other works of reference; and those in which a more or less comprehensive survey of the entire literature, or a considerable portion of it, must be made.

Short Searches.—Suppose, in the first instance, that one wishes to know the physical and chemical properties of butyl alcohol. This compound has been known for a number of years, and its properties have been determined and recorded in periodicals for a sufficient length of time so that one should be able to find the desired information in the general works of reference, excepting the possibility of some fact recently discovered. Accordingly, a search would be made in the tables of physicochemical constants already described for data on such constants as boiling point and refractive index. One would not expect to find in these tables—"International Critical Tables," for example—the chemical properties; rather, they should be sought in a treatise on organic chemistry, such as Beilstein's "Handbuch der organischen Chemie."

The identification of organic compounds may be taken as another kind of problem. Having determined the empirical

[1] See Berolzheimer, *The Chemist*, **13**, 426 (1936), for valuable advice on searching by one unusually skilled in the art.

[2] See Molstad, *Ind. Eng. Chem., News Ed.*, **16**, 206 (1938), for a general summary of sources of information, especially on economics, engineering, and administration.

[3] Smith, *J. Chem. Education*, **4**, 1522 (1927).

formula, the chemist may then turn to the formula indexes of Richter's "Lexikon," Stelzner's "Literatur-Register,"[1] and *Chemisches Zentralblatt* or *Chemical Abstracts* to ascertain what compounds of this formula are known. It then remains for him to compare the properties of his compound with those of any found in this way. In cases of this kind special works are frequently available, such as Meyer's, "Lehrbuch der organisch-chemischen Methodik."

Again, it may be necessary to find a method for preparing some compound, as sodium perchlorate, or to introduce a nitro group, let us say, into some compound containing the benzene ring. In cases such as these, the desired information may generally be found by consulting the large, general works of reference covering the field to which the problem belongs. These works include the treatises and encyclopedias mentioned in Chap. VIII. As Hibbert points out,[2] it is important to bear in mind that all methods of preparation are not equally satisfactory for all purposes. One may have to produce a very pure product and not be concerned with obtaining a yield of 95 per cent. On the other hand, a method giving a yield of 95 per cent may be the salvation of an industry if it is competing with another using a method giving a yield of 85 per cent. If it is a problem involving the necessity of finding the best method or of devising a special kind of method, a more detailed search, as described below, is generally required.

What has been stated regarding the above-mentioned specific examples applies, in general, to similar problems, whether the field of chemistry in which the problem lies is general, inorganic, analytical, organic, physical, or some other division of pure or applied chemistry. Use is made primarily, of course, of any reference works dealing especially with the field under consideration, following this, if necessary, with consultation of works on related phases of the subject. If the method desired should be of recent development, the works of reference are usually too old to include it, and one should then go directly to the abstracting journals, as indicated later. However, if the method is

[1] Vol. 29, the formula index of the Beilstein treatise, now covers the material to 1920.

[2] *Chem. Met. Eng.*, **20**, 578 (1919).

not so new, it may not be necessary to go to the original literature unless it seems desirable to compare the statements found in the works of reference with those of the original.

A consideration of sources of information bearing on some of the questions a chemist takes to the library, as outlined in Chap. I, may be of value as further examples of short searches. For these there is included only a statement of the question and the publications likely to be of value in finding information thereon.[1]

1. *References on the Corrosion of Alloys by Ammonia.*—Published bibliographies, such as those of West and Berolzheimer or Van Patten; special works bearing on corrosion; abstracting journals.

2. *Life of Berzelius.*—Histories of chemistry; biographical articles in periodicals; and, were he an American, such biographical sources as "American Men of Science," "Who's Who in America," and "Who's Who in Chemistry," as well as "Who's Who," "Dictionary of National Biography," and Lippincott's "Biographical Dictionary."

3. *Fluorine Substitution Products of Methane.*—Determine the compounds theoretically possible and consult organic formula indexes of Richter, Stelzner, Beilstein, and *Chemical Abstracts* (or *Chem. Zentr.*).

4. *Occurrence of Barytes in Canada.*—Works on mineralogy and geology; "Minerals Yearbook."

5. *Formula for Automobile Lacquer.*—General encyclopedias; cyclopedias of formulas; special treatises or monographs on paint and varnish industry; abstracting journals.

6. *Waterproofing Stone and Brick.*—Encyclopedias; special works on building materials and ceramics; chemical patents (see Chap. IV); abstracting journals.

7. *Action of Charcoal as a Purifying Agent.*—Treatises on theoretical and physical chemistry; works dealing with the chemistry of colloidal systems, particularly adsorption; such topics as decoloration and clarification in encyclopedias and special industrial works; patents; abstracting journals.

8. *Use of Sawdust.*—Special works on the chemistry and technology of wood, especially publications of the U. S. Forest Products Laboratory; encyclopedias; patents; abstracting journals.

9. *Analysis of Flue Gas.*—Special works on gas and fuel analysis; general works on technical analysis; publications of the U. S. Bureau of Mines; encyclopedias; abstracting journals.

10. *Statistics on Lampblack Industry.*—"Minerals Yearbook"; census reports; circulars from U. S. Bureau of Foreign and Domestic Commerce; current market reports; abstracting journals.

[1] Further ideas may be obtained from the problem assignments in Chap. XI and the sources suggested at the end of the lists.

Comprehensive and Exhaustive Searches.—In many instances, having defined the nature, purpose and scope of a problem, it is necessary to gather all the available information relating to the whole subject involved, or to certain phases of it, either for the entire period covered by chemical literature or for some definite part of this period. Searches of this kind will usually involve the use of both original and secondary sources of information.

Before starting a comprehensive search it is well to have some idea of the approximate degree of completeness desired. In some cases one wants everything known; in others only the significant facts from a given date to the present time are sufficient. As stated in Reid's book,[1]

> It is well to realize that, at present, few searches of scientific and technical literature are ever complete. The practical question, then, is merely how far one can or ought to go in a particular case. According to the nature of the subject and the object with which the search is undertaken a point will always be reached, eventually, where all competent judges must agree that the probability of finding a reference and its possible value if or when found do not warrant the time, trouble or expense involved in continuing.

It would be a waste of time, for example, to search for the application of the vacuum tube in chemical measurements before the time of the invention of the tube.

Different individuals will begin such a search in different ways, although each seeks the same goal—all the relevant facts in the case. Whatever the method used, it should meet the tests of accuracy, dependability, and efficiency. Some individuals recommend starting with the earliest publications available relating to the problem in hand. By means of indexes, reviews, and abstracts they work forward to date. Others practically reverse the procedure, beginning with the latest indexes and working backward as far as seems profitable. The procedure described below is essentially the practice followed by the writer.

Assuming that all the pertinent facts on a given subject are to be collected, it is probably a question whether one should start on the works of reference or in the indexes of the abstracting journals. Doubtless the former should be consulted first in

[1] "Introduction to Organic Research," p. 140 (1924).

many cases; a concise, recent summary of information on the topic under consideration, such as those in *Chemical Reviews*, general review serials, encyclopedias, and monographs, may be of much value in providing a background for beginning the more extended search. More frequently, the writer begins with the last indexes of the abstracting journals. One important advantage of this lies in the fact that one is liable to find in recent articles a bibliography bearing directly upon the subject in question. It should be stated that, even before starting with the indexes, all available lists of bibliographies, such as that of West and Berolzheimer, are searched for compilations promising to be of value.

It is desirable at this point, or before the search of the index has progressed far, to make an outline of the possible headings which may furnish information of value. A systematic search under each of these should then be made, noting all references which offer any promise of containing desired material. In general, the only safe way is to include all uncertain references until abstracts, or the original, indicate they are irrelevant. Having selected from the indexes all references seeming to have any bearing on the subject, the abstracts are then read. Whenever the abstract indicates that the reference is obviously without value it is discarded. All others are recorded, each on a separate card, as indicated later, and filed.

Usually alphabetical filing by authors will be found most desirable. Often nothing more is needed; but in some cases, especially when many references are involved, it is preferable to adopt some system of subdividing the cards. This may be by years, countries, periodicals, natural divisions of the subject, or other suitable classification. In each of these the filing would then ordinarily be alphabetical by authors.

Although one may expect abstracts to furnish a general statement of the contents of the publication abstracted, it is always well to maintain a skeptical attitude toward them. In many cases, probably the majority, they do not furnish the desired details. Unless it is reasonably certain from an inspection of the title of the publication, and of abstracts of it, either that nothing of interest is contained therein, or that all desired information is provided thereby, the original publication should be consulted

if possible. In case the original is unobtainable, several abstracting journals giving abstracts for the same article may help considerably.

In some instances all the indexes of *Chemical Abstracts* and other abstracting journals are examined in this way before one starts to read original articles. (Collective indexes for periodicals should always be used if available.) At other times some of the readily available articles, books, and handbooks are read after the collection of only part of the references in the abstracts. Just as soon as the reading is begun the references branch out in all directions, since each author will have included those he considered significant. All those of value for the problem being investigated are recorded and put in the same file. Perhaps the better way is to divide the file into two sections, putting all references which have been examined and checked in one list and those to be examined in the other. The advantage of such filing appears soon after starting. If a reference is found when an article is being read, no record is made until the alphabetical list is examined to ascertain whether such an entry has not already been included, for one will often find the same reference in a number of different papers. In this way all references are put in the list as found, and duplication of cards is avoided.

The four main abstracting journals for general searches are *Chemical Abstracts*, *Chemisches Zentralblatt*, the *Journal of the Chemical Society* and the *Journal of the Society of Chemical Industry*, the latter two now being issued jointly as *British Chemical and Physiological Abstracts*. A number of others, having less significance or covering a more specialized field, are mentioned in Chapter VII.

Whether one begins with the abstracting journals or with other types of publications, ultimately both will be used in making a comprehensive search. Each individual will reach his own decision regarding the most efficient practice for his type of problem. In any case, a systematic handling of notes on the references is desirable.

Although this fairly systematic method of searching is, as a rule, most efficient and should generally be followed, simply looking about, more or less at random, is frequently productive of valuable information. In the case of general books one may

look here and there, selecting for examination whatever works offer promise of interest; for periodicals it may be worth while, as a last resort, to leaf through the volumes, page by page. This is a tiresome, time-consuming task, but one may find just the formula, equation, or other readily apparent item which is desired, when an examination of the titles of articles and the indexes indicated nothing of value.

As far as possible, one should develop the ability to go through the original publications rapidly, selecting at the same time the significant points for the search in hand. This is not an easy task, the development of efficiency in it requiring considerable practice. Since the individual familiar with the problem involved knows better than any one else what is significant, other things being equal, he is the best fitted to conduct this part of the search. One not thinking along the line of investigation involved can hardly be expected to sense the importance of the various points encountered, or to be alert in following what may seem at first only unpromising side issues.

Recording Information.—The method to be used in recording the information obtained during a search is of some importance also. A useful scheme is to employ a card file of convenient size, using cards of bond paper, cut to the desired dimensions, from a stock of the desired weight. Three- by five-inch sheets may be used although the 4- by 6-in. size affords more room for writing. Such paper is thinner than the ordinary cards.[1] On each one of them is recorded the required information, as indicated in the form shown below.

Form for Filing Card

Author's name	Bibliography
Original reference	Abstract reference

Title of publication

Notes

The reference contains the standard abbreviation, if a periodical, or the title, if a book, including volume, page and year. In the upper right-hand corner is a word to indicate the nature of

[1] Library Bureau cards, No. 1192 (3 by 5 in.), unpunched and without vertical lines are very satisfactory.

the bibliography so that different ones can be easily separated if the references happen to become mixed. The reference to the abstracting journal enables one to return quickly to the periodical if desired. The notes include any facts likely to be of value.

When the reference is first taken down from the abstracting journal, or other source, and filed, only the items at the top are recorded. If, on consulting the original source, nothing of value is found, a check is placed in one corner to indicate such examination, but no further entry is made. Keeping the card in the file saves repeating the examination at some later time, if the reference is not recognized when encountered again. If the material is of value, the title is taken down, along with the notes and the card is checked.

In some cases a more efficient plan is to have one or more extra subscriptions to *Chemical Abstracts* to provide copies for clipping. Any abstracts of interest may be cut out, pasted on filing cards, and put in the proper place. One needs to add only the abstract reference, if desired, and the bibliographical heading.

Dependability.—Only the completely credulous individual uses the scientific literature without questioning the reliability of the information recorded therein. Undoubtedly the material printed is not all correct, or always the best obtainable; but in general the achievement in this respect is believed to be high. Nevertheless, in examining every contribution a critical searcher will maintain a skeptical attitude.

To judge the reliability of another's work may be difficult. Wide experience and knowledge on the part of the critic are of great value in providing perspective. For writers of reputation he will be influenced by the quality of their previous contributions. In experimental work the technique used is an indication of general quality. The conclusions reached by an author should be examined in light of the facts upon which they are based. All references should be verified, as many otherwise careful writers are negligent in checking the accuracy of their citations.

Reports on Information Found.—If one merely collects all the references available bearing on a given problem, he has at hand the fundamental material for a bibliography on this problem. To make this material readily usable for selecting and looking up the references desired, there remains only the problem of

arranging the references in some one of the ways suggested in Chap. VII. If the various references have been examined sufficiently to provide for the inclusion of carefully prepared annotations for each citation, the bibliography as such may constitute a satisfactory report of the search.

But if the bibliography, when properly prepared, does not in itself constitute a sufficient presentation of the material covered, it becomes necessary to prepare a more general type of report. In such a case it will take one of two forms: noncritical or critical. If it is noncritical, there is included for the work of each investigator a statement of what he did (including how he did it, if important experimentally) and the conclusions reached. A critical report, on the other hand, is distinguished by its emphasis on the relative merit or value of each contribution. In this connection one should keep in mind, of course, that, while one report may be entirely noncritical, the extent to which another is critical is a question of degree. Probably in few cases is the best possible approached.

For instructions regarding the preparation of reports the reader should consult Library Problem 19, page 235, including the references mentioned there.

CHAPTER XI

LIBRARY PROBLEMS

A competent searcher should have at his command a knowledge of libraries, including where they are and what is in them, combined with an ability to find and to use the information sought.—*Berolzheimer.*

It has already been pointed out that lecturing to a class on the contents of a library, and on the method of using the material contained therein, will not leave a very lasting impression upon the individual or make him proficient in finding desired information. Lectures and discussions may suffice to give him a general idea of the problem in hand, but practical experience in handling the various sources of information is of prime importance in gaining a knowledge of how to find desired material in a library. What is true in this field of endeavor is true in many others. One can hardly expect, for example, to learn how to make precise chemical analyses by attending lectures dealing with this subject. Actual experience in the laboratory is the *sine qua non* in obtaining an intimate acquaintance with the work.

In general, it is desirable to give each student an individual assignment.[1] He should have his own special material to locate rather than copy the work of another. By a proper selection of assignments, the instructor has the opportunity not only of having him gain some familiarity with the place and the method for finding definite information in chemical publications, but also of broadening his general knowledge of chemistry. When the work comes in the third year, it is comparatively easy to have most of the assignments made to material that is quite new to the average individual at this stage of his chemical training.

A number of special form pages have been included in this book for the purpose of providing library problems for a course

[1] MELLON, *J. Chem. Education* **2**, 196 (1925).

on chemical literature. Also there are included lists of representative assignments which may be used in connection with the proper form pages or library problem sheets. In the different lists it will be found that the various assignments are not all of equal difficulty.[1] Thus Problems 6 and 8 require more knowledge of chemistry and of foreign languages than Problems 5 and 7. Undergraduates may be excused from those for which their educational preparation is inadequate.

Students who have sufficient interest to try to do something more than just meet the minimum requirements in the course should be encouraged to browse around in the library. Although the acquisition of the information required for a specific assignment should result in some extension of the searcher's experience and knowledge, an alert student will avail himself of this opportunity to leaf through the work consulted in order to gain at least a general idea of the publication and its contents. Preferably several works in the same field should be examined sufficiently to observe the general plan and to note their differences and similarities.

Following many of the lists there is a note to indicate at least one source in which the required information may be found. Often an industrious student will discover other usable sources.

[1] *To the Instructor.*—For a class meeting once a week for a semester of 16 weeks the 19 problems given probably will be sufficient for the average student. This provides practically one problem per week. A maximum of 2 weeks may be allowed for the completion of each problem.

It is desirable for the instructor using any new problems to verify the assignments which are made. A student's interest is not enlivened if he finds, after several hours search, that his assignment was not properly made, or that it cannot be found.

In the writer's experience, it has been found convenient in making the assignments, using lists such as those included in this book, to indicate simply that a given individual is to take, for his problem, a given number throughout the lists. In case additional assignments are to be made, the following procedures are suggested: (1) post similar, numbered lists, each student having been given his number; (2) at the time the book is submitted for the inspection of one problem write in the assignment for another; or, (3) distribute to each student at class time a slip of paper containing his name and assignment. This should be returned when the problem is submitted for inspection.

Instructors who adopt this book as a text may arrange with the author to share his more extensive lists of problems.

Library Problem 1[1]

Periodicals I

1. Supply, for the abbreviation indicated, the required information concerning the journal

   a. Abbr.....

   b. Name.....

   .....

   c. Country.....Language.....

   d. Frequency of appearance.....Present volume.....

   e. Volume.....appeared in the year.....

   f. Nearest library containing journal.....

2. .....

   is the official abbreviation for the journal.....

   .....

   Its contents may be classified as follows:

[1] For assignments, see p. 237.

3. Supply the information indicated for two important.....

journals publishing articles on.....

.....

a.[1] Name.....

.....

Country.....Place edited.....

Frequency of appearance.....Present volume.....

b.[1] Name.....

.....

Country.....Place edited.....

Frequency of appearance.....Present volume.....

4. During the year.....the following article appeared on.....

.....

Title.....

.....

Author(s).....

Professional connection(s).....

Abstract reference.....

.....

Original reference[2].....

.....

[1] Write in full, underscoring the official abbreviation.

[2] Write in full, underscoring the official abbreviation (include series, volume, page, and year).

Library Problem

Periodicals II

1. In[2].....the price of.....was.

   For the year.....the price range is shown by the following curve:

   Jan. Mar. May July Sept. Nov.

   Source.....

2. The firms indicated, according to current advertising, can furnish the following equipment.....

   Source.....

3. A book review for.

   .by.

   was written by.....and published in

[1] For assignments, see p. 238.
[2] Indicate month and year.
[3] Supply price unit and ordinate markings.

4. The accompanying abstract[1] is from an article by.....

published in.....

[1] Follow the general form employed in *Chemical Abstracts*.

Library Problem 3[1]

Institutional Publications

Information regarding the items noted may be found in the sources given.

1. Reports of investigations on.....

   a. Title of source.....

   b. Author(s).....Date.....

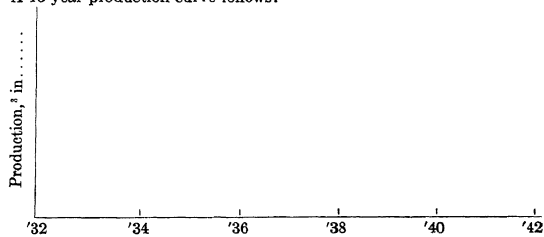
   c. Dept. of Gov't.....Bureau.....

   d. Designation[2].....

2. In the year.....the U. S. produced.....of.....

In the source given, other data concerning domestic production includes

A 10-year production curve follows:



Source.....

[1] For assignments, see p. 240.

[2] Kind of publication—*e.g.*, *Bull.* 20.

[3] Supply production unit and ordinate markings.

3. Information for the year.....on foreign activities in.....

for.....includes

Source.....

4. In the year.....the U. S. imported (exported).....

of.....valued at.....

The two countries (states, cities) having the largest trade were.....

Source.....

5. Statistics for the year.....on the domestic production of.

a. No. of establishments.....*c.* Total production.

b. Value of products.....*d.* Unit value.....

Source.....

6. Statistics relating to the.....

industry in.....for the period.....

a. Capital.....*d.* No. of establishments.

b. Taxes.....*e.* Value of products.....

c. Rank of state.....*f.* Cost of materials.....

g. Other general statistics for the industry

Source...

Library Problem 4[1]

Literature on Patents

1. Supply the information indicated for a patent issued (abstracted) during the year.....relating to.....

   Patent title.

   Abstract reference.....

   Patentee(s).....No.....

   Country.....Date.....

2. The following information is for.....Patent No.

   Patent title.....

   Patentee(s).....Date.....

3. For a U. S. chemical patent[2] supply the information indicated:

   Patent title.....

   Official Gazette reference.....

   Chemical Abstracts reference.

   Patentee(s).....

   No.....Date of issue....

[1] For assignments, see p. 242.
[2] To be obtained from the U. S. Patent Office.

Outline of specifications:

Description or disclosure

Claims

Library Problem 5[1]

Physical Constants I

In the sources noted (author, title, volume, page, date) one may find, for the designated substance or property, the information indicated.

1. .....

   Mol. wt.....M.pt.....B.pt.....Sp.g.....

   Other data.....

   Source.....

2.

   Solubility in.....at...°C.

   Investigator.....

   Original reference.....

   Source.....

3.

   Sp.g.....Iodine No.....Refractive index.

   Solidifying point.....Hehner value.....

   Optical rotation.....Saponification value..

   Source.....

4.

   Heat of soln.....Heat of formation...

   Specific heat.....Heat of combustion.

   Source.....

[1] For assignments, see p. 243.

5. Substances possessing the following physical property:

M.pt. .B.pt.

Refractive index (liquid).....Density (liquid).

Source.

.....is the sp.g. of a.....per cent aqueous solution of.....The Baumé reading for a 10 per cent solution of this substance is.....

Source.....

7. The most generally useful chemical engineering data on.

.include

Source.

Library Problem 6[1]

Physical Constants II

In the sources noted (author, title, volume, page, date) one may find, for the designated system, the information indicated.

1. For the compound whose formula is.....
   the I.C.T. key formula is..... .....having the key
   numbers.....It is listed in.....Table, p.....
   Source.....

2. I.C.T. data (general) on.....include

   Compiler.....Scientific field.....
   Position.....Age.....
   Source.....

3. I.C.T. data (specific) on.....include

   Investigator.....
   Original reference.....
   Source.....

[1] For assignments, see p. 245.

4. In the Landolt-Börnstein set one may find

a. In the main work and supplements collected data on

.....

Hauptw., Part.....p.....yr.....Erg. I, p.....yr.....

Erg. II, Part.....p.....yr.....Erg. III, Part.....p.....yr.....

b. The following specific data.....

.....

Investigator.....

Original reference.....

Landolt-Börnstein reference.....

References to other parts of this set for the same assignment

5. Collected data published (in French) during.....on

.....include

Investigator.....

Original reference.

Source.....

Library Problem 7[1]

Organic Chemistry I

1. The chemistry of the compound named.....

and having the formulas (empirical).....

and (structural).....may be found in

a.[2] Whitmore, "Organic Chemistry," p....( )

b.[2] Richter (von), "Textbook of Organic Chemistry," V....p....( )

c.[2] Meyer and Jacobson, "Lehrbuch der org. Chem.," V....p....( )

d.[2] Grignard, "Traité de chimie organique," V....p....( )

e.[2] Heilbron, "Dictionary of Organic Compounds," V....p....(

[1] For assignments, see p. 248.
[2] Include a statement of the references to the original literature as found.

2. The name.....

(International Union of Chemistry) may be applied to the compound having the formula.....

Source.....

3. In the sources noted the following information may be found:

a. In the year.....the following references dealing with the compound.....were abstracted:

Source.....

b. The transformation known as.....

reaction (process, synthesis, test) is (with specific example)

Source.....

c. A general discussion on the subject of.....

.....

Source.....

d. The chemical equation for the reaction of.....

.....with.....is

Source.....

Library Problem 8[1]

Organic Chemistry II

1. For the compound whose name is.....

and whose formulas are (empirical).....

and (structural).....the

following references, with interpretations indicated, may be found in

a. Richter, "Lexikon der Kohlenstoff-Verbindungen," V....p....( )

a'. .....

.....

b'. .....

.....

c'. .....

.....

d'. .....

.....

b. Stelzner, "Literatur-Register der org. Chem.," V....p....( )

a'. .....

.....

b'. .....

.....

c. Chemisches Zentralblatt (or *Chemical Abstracts*)[2]

[1] For assignments, see p. 250.
[2] Formula index only.

2. A critical discussion of the chemistry of this compound, with references to the original literature as noted, may be found in

Beilstein, "Handbuch der organischen Chemie," Hw., V....p....( );

Erg. I, V....p....( ); Erg. II, V....p....( )

According to Beilstein's classification,[1] this compound is in

Division.....Subdivision.....
(Skeleton name) (Kind and no. of heteroatoms)

Class.
(Number) (Name and formula of functioning group)

Subclass.
(Letter) (Name)

Rubric.....
(Number) (Name) (General formula)

Series.....System number.....
(No. of carbon atoms)

Index compound.....

3. In the source noted one may find

a. The formula (name) of the organic radical.....

Source.....

b. The following information on the.....ring complex

No. of component rings.....Members.....
(No. of elements in rings)

Heterocyclic rings.....Carbocyclic rings.....

Parent compounds of this configuration.....

Source.....

[1] Reference is to the fourth edition of the Beilstein set.

Library Problem 9[1]

Inorganic Chemistry

1. The compound named.....

has the formula.....

a. The following references, with interpretations indicated, are in

a'. Hoffmann, "Lexikon der anorg. Verbdgn.," V....p.....( )

a''. .....

.....

b''. .....

.....

c''. .....

.....

d''. .....

.....

b'. *Chemical Abstracts* (or *Chem. Zentr.*) Formula Index

b. A critical discussion of the chemistry of this compound, with references to the original literature as noted, may be found in

a'. Mellor, "Treatise on Inorg. and Theor. Chem.," V....p....( )

For assignments, see p. 251.

b'. Gmelin, "Handbuch der anorg. Chem.," ....V....p....( )

c'. Friend, "Textbook of Inorg. Chem.," ....V....p....( )

d'. Abegg, "Handbuch der anorg. Chem.," ....V....p....( )

e'. Pascal, "Traité de chimie minérale," ....V....p....( )

2. The known compounds of.....include

Source..

Library Problem 10[1]

Analytical Chemistry

In the sources noted one may find the following information:

1. Procedures for the qualitative tests for.....

   a. Characteristic reactions

      a'. .....

      b'. .....

         Source.....

   b. Methods of detection

      a'. .....

      b'. .....

         Source.....

2. Methods (classified to indicate the methods of measurement and separation,[2] *e.g.*, Ca, gravimetric precipitation) for the determination of.....

Source.....

[1] For assignments, see p. 252.

[2] Mellon, "Methods of Quantitative Chemical Analysis."

3. A.....method[1] for determining

.....in.....consists in

Source.....

4. Directions for the analysis of.....

Source.....

[1] A specific kind of measurement may be assigned.

Library Problem 11[1]

Industrial Chemistry I[2]

In the sources indicated the following information may be found:

1. Two books dealing with.....

   a. .....

   b. .....

   Source.....

2. The product whose brand (trade) name is.....

   is manufactured (sold) by.....

   located at.....

   Source.....

3. Two firms which manufacture.....equipment

   a. .....

   b. .....

   Source.....

4. The scientific (trade) name of.....

   is.....

   Source.....

5. The cost of.....

   is approximately.....

   Source.....

[1] For assignments, see p. 253.

[2] For more extensive industrial problems, see Kobe, *J. Chem. Education*, **10**, 679, 738 (1933); **11**, 40, 108 (1934).

6. Two published bibliographies on.....

   a. .....

   b. .....

   Source.....

7. Two firms that sell the chemical.....

   a. .....

   b. .....

   Source.....

8. Two important chemical manufacturing firms in.....

   a. .....

   b. .....

   Source.....

9. A commercial method of making.....

   is.....

   Source.....

10. Historical facts concerning.....

    Source.....

Library Problem 12[1]

Industrial Chemistry II

In the sources indicated the following information may be found:

1. A review of developments for the year.....for.....

.....includes the topics

Source.....

2. Two sources of supply of the raw material (specialty).....

a. .....

b. .....

Source.....

3. The composition of.....

Source.....

4. The commercial grades of.....are

Source.....

[1] For assignments, see p. 255.

5. Three commercial uses of.....are

   a. .....

   b. .....

   c. .....

   Source.....

6. A manufacturer's technical publication on.....

   covers

   Source.....

7. Miscellaneous information for.....includes

   Container.....

   Shipping regulation.....

   Tariff.....

   Source.....

8. Specifications for..... .....include

   Source.....

9. Chemically resistant materials for handling.....

   consist of

   Source.....

Library Problem 13[1]

Dyes[2]

State the information requested for the dye.....

Schultz No.....Color Index No.....

Manufactured by.....

Formula

Scientific name.....

Other names.....

.....

Method of preparation

[1] For assignments, see p. 258.
[2] Suggested by G. H. Richter.

Uses

Fastness

Materials dyed

Absorption spectrum

Other data (statistics, etc.)

Library Problem 14[1]

Metallurgy and Metallography[2]

In the sources indicated the following information may be found:

1. Two common ores of.....are

   .....

   The most important commercial sources are

   Source.....

2. Two methods of treating.....ores are (with chemical reactions)

   Source.....

3. Important uses for.....are

   Source.....

4. Two books on.....
   (with author, title, publisher, date)

   Source.....

[1] For assignments, see p. 259.

[2] See RIMBACH, "How To Find Metallurgical Information" (1936).

5. Chemical composition of the alloy.....

Source.....

6. The equilibrium diagram for an alloy containing.....

Source.....

7. The physical properties of.....

Source.....

8. The corrosion resistance of.....to.....

Source.....

9. The current price of.....

Source.....

Library Problem 15[1]

Medical and Pharmaceutical Chemistry

In the sources indicated the following information may be found:

1. For the drug.....

   a. Two sources of supply

   b. The essential chemical compound(s) in it

   c. Its most important physiological action(s)

   d. The commercial method of treatment or preparation

   e. Its pharmaceutical uses

Source.....

[1] For assignments, see p. 261.

2. The U.S.P. specifications for.....

Source.....

3. Two manufacturers of.

Source.....

4. The current price of.....during the year.

Source.....

5. The composition of.

Source.....

6. A method of analysis (or testing) for.

Source.

Library Problem 16[1]

Economic Survey of a Chemical Commodity[2]

Raw Materials

Sources of supply

a. Common sources.....

b. Other possibilities.....

Specifications.....

Tonnage requirements for economical handling.....

Manufacture

Methods (with flow sheets for commercial plants).....

Control tests.....

Production costs (itemized statement).....

By-products (including utilization or disposal).....

[1] For assignments, see p. 263.

[2] In industrial chemistry, instead of confining the problem to collecting individual technical facts, as in Problems 11 to 15, often it is desirable to make an economic survey in the form of a more general report. To compile the information will require the use of some of the sources recommended for the preceding specialized problems, but certain others will be necessary for financial facts. If this problem is to be a finished term report rather than merely a compilation of facts, it might well be combined with Problem 19. The outline followed is based on a paper by Kobe, *J. Chem. Education*, **10**, 738 (1933).

Finished Product

Usual purity.....Grades.....

Shipping containers.....Shipping regulations.....

Specifications required.....

Physical properties.

Chemical properties.

Industrial uses.

Items of Commercial Importance

Domestic production.....

Domestic consumption.

Imports (amount).....From.

.....Tariff.

Exports (amount).....To....

Names and location of 5 manufacturers.

Graphical comparison of monthly selling price with weighted index of prices of all commodities (See *Chem. Met. Eng.*)

Financial Report on One Manufacturer

Firm.....

Rating:

a. Dun and Bradstreet[1].....

b. Moody[2].....

Stocks and bonds outstanding.....

Stocks listed on exchange at.....

Graph of earnings and dividends per share (for 5-year period).....

Graph of stock activity (10-year period).....

[1] "The Mercantile Agency Reference Book."
[2] "Moody's Manual of Investments," volume on Industrial Securities.

Important items in last financial report (date.....)

Conclusions

Library Problem 17[1]

Miscellaneous Information

In the sources indicated the following information may be found:

1. Biographical facts concerning.....

   Dates of life.....Nationality.....

   Field of chemistry.....

   Important contributions

   Source.....

2. The significance in chemistry of the two abbreviations.

   b. .....

   Source.....

3. A summarized discussion of our present knowledge of.

   Source.....

4. The occurrence (or sources) of.

   Source.....

[1] For assignments, see p. 263.

5. A popular publication on.....

Source.....

6. A recipe for.....

Source.....

7. The reaction of.....

Source.....

8. Experimental methods for.....

Source.....

9. A laboratory method for preparing.....

Source.....

Library Problem 18[1]

Preparation of a Bibliography

The previous problems have been designed to familiarize the student, to some extent at least, with the general nature of the different kinds of publications and with their use in finding information relating to the various questions which a chemist takes to the library. An individual should be able not only to locate special facts and data which he desires but also to make a general survey of the recorded available information on a given subject and to prepare an acceptable report containing a statement of the important points revealed by the survey.

In general, the first step in making such a survey is the compilation of a partial bibliography. As mentioned in Chap. VII, occasionally good lists of references are already available as a starting point, but in connection with the discussion of this problem it will be assumed that such is not the case. For the preparation of a bibliography, as an exercise for a library problem, several points should be considered, such as the following:

1. Selection of the Subject.—The student should be urged to select his own subject, as it is then more liable to have a personal interest for him. For those who have no subjects of their own, a list of suitable subjects should be available from which to make selections.

2. Determination of the Scope of the Subject.—Many subjects suggested prove to be either too limited or too broad in their range; that is, too many references will be found to handle in the time available, or too few can be located to give any opportunity for working out a classified bibliography. Although a complete bibliography, even on a comparatively little used element, such as selenium, is rather extensive, the list is much less imposing when the subject is confined to the organic compounds of selenium.

3. Determination of the Scope of the Bibliography.—If a bibliography is not to be complete, one must decide which portion of the whole field of the literature is to be covered. When the compilation of a bibliography is merely a part of a

[1] For assignments, see p. 265.

course on chemical literature, a large amount of time is not available. Ordinarily, the location of approximately 100 references will give the student sufficient experience in this type of work.

4. Determination of the Bibliographical Details to Include.—Ordinarily the following items should be recorded for each entry: author (or patentee); original reference, including, if a periodical, its official abbreviation, series, volume, page, and year; or, if some other kind of publication, such information as will indicate unmistakably the source of the material; abstract reference, the abbreviation, volume, and page being sufficient; title of article (or other publication); and annotations if the title does not give a sufficient clue to the nature of the contents.

5. Method of Searching.—General directions for searching are included in Chap. X. It is valuable experience for a student to be turned loose at this point, with an occasional guiding suggestion, in order to determine what he can find on a given topic. The report should contain a list of the index headings examined during the search for references.

6. Arrangement of Material.—The usual forms of arrangement used in bibliographies are discussed in Chap. VII. Here again the student should probably be left to his own devices not only in the arrangement of the details on the page for each entry, but also in the classification or listing of the references as a whole. If the various bibliographies mentioned in Chap. VII are available for examination, the merits of the different schemes can be ascertained.

Library Problem 19

Preparation of a Critical Report

The previous assignments have dealt primarily with the problem of locating required information in the various sources available. Very often one needs not only to find specific facts, but also to make effective use of them in a report.

Let us assume that an ordinary problem of chemical research is undertaken. The general scope of the problem is first determined. Then one usually wants to ascertain what is already known concerning it so that he may begin somewhere near the point where others quit. This involves searching chemical publications and the collection of material. On the basis of this knowledge experiments are planned, if necessary, and executed, resulting in the accumulation of more data. A final report of the work will frequently include the following points: a statement of the problem; a review of others' work bearing upon it; new experimental work performed, including the data secured; a general discussion of the results, including their connection with previous work; and the general conclusions.

In preparing the review of others' work, the compilation of a bibliography, as given in Library Problem 18, is only a part of the whole task. True, it may require much time and considerable ingenuity in searching; but something more is required if one is to avoid being submerged in the waves of facts and is to get his bearings by gaining a perspective of a considerable portion of the sea around him. The references must be examined; and the material in them must be sifted, classified, correlated and evaluated. With respect to the facts involved, we must, in the words of Glenn Frank, find them, filter them, focus them, face them, and follow them.

The preparation of a concise review of the information available on some simple problem is suggested as the logical assignment to follow the preparation of a bibliography. The field of the bibliography submitted for Library Problem 18, if not too extensive, or some definite portion of it, may well be taken.

The problem and the technique of preparing the manuscript for such reports have been considered in detail in several other

publications. For general information of this kind the student is referred to the sources listed below, which deal not only with the type of report just discussed but also with the preparation of articles or books, including the final process of printing.

References

ALLEN, "The Author's Handbook" (1938), International Textbook.

ALLBUTT, "Notes on the Composition of Scientific Papers" (1923), Macmillan.

ALMACK, "Research and Thesis Writing" (1930), Houghton Mifflin.

ARKIN and COLTON, "Graphs" (1936), Harper.

BAKER and HOWELL, "Preparation of Reports" (1938), Ronald Press.

BRINTON, "Graphic Methods of Presenting Facts" (1919), Eng. Mag. Co.

CAMPBELL, "A Form Book for Thesis Writing" (1939), Houghton Mifflin.

COLE and BIGELOW, "Manual of Thesis Writing" (1934), Wiley.

FULTON, "Expository Writing" (1930), Macmillan.

GREENOUGH and HERSEY, "Writing Well" (1932), Macmillan.

HOSHALL, *J. Chem. Education*, **11**, 21, 154, 235, 546 (1934), Chemical Drawing.

KIBLER, *ibid.*, **13**, 525 (1936), The technical report.

LANE, "Suggestions to Authors" (1935), U. S. Geol. Survey.

MCDONALD, "English and Science" (1929), Van Nostrand.

MUELLER, "A Manual of Drawing for Science Students" (1935), Farrar & Rinehart.

NELSON, "Writing the Technical Report" (1940), McGraw-Hill.

PARK, "English Applied in Technical Writing" (1926), Crofts.

PERRY, "Chemical Engineers' Handbook," Sec. 29, Report Writing (1934), McGraw-Hill.

REEDER, "How to Write a Thesis" (1930), Public School Pub. Co.

REID, "Introduction to Organic Research," Chap. XVIII (1924), Van Nostrand.

RICKARD, "Technical Writing" (1923), Wiley.

SOULE, "Library Guide for the Chemist," pp. 263–70 (1938), McGraw-Hill.

TRELEASE and YULE, "Preparation of Scientific and Technical Papers" (1936), Williams and Wilkins.

WATT and MUNN, "Composition of Technical Papers" (1935), McGraw-Hill.

"Manual of Style" (1932), Univ. of Chicago Press.

"Style Manual of Government Printing Office" (1933), U. S. Govt. Ptg. Off.

Assignments for Library Problem 1

Part 1. Standard abbreviations for periodicals.

1. *Acta Dermatol.*
2. *Chaleur et ind.*
3. *Deut. Zuckerind.*
4. *Quim. e ind.*
5. *Sovet. Met.*
6. *Monatsh.*
7. *Ind. carta*
8. *Atelier Fot.*
9. *Arch. fisiol.*
10. *J. usines gaz*
11. *Jahrb. Milchw.*
12. *Rev. prod. chim.*
13. *Bull. inst. pin.*
14. *Nord. Tid. Fot.*
15. *Ind. chim. belge*
16. *Roczniki Farm.*
17. *Klin. Wochschr.*
18. *Seiikai Med. J.*
19. *Svensk Farm.*
20. *Ann. fals.*

(Consult "List of Periodicals" abstracted by *Chemical Abstracts.*)

Part 2. Names of journals.[1]

1. *Journal of the American Chemical Society.*
2. *Journal of Physical Chemistry.*
3. *Industrial and Engineering Chemistry.*
4. *Chemical and Metallurgical Engineering.*
5. *Journal of the Chemical Society.*
6. *Chemistry & Industry.*
7. *Berichte der deutschen chemischen Gesellschaft.*
8. *Zeitschrift für analytische Chemie.*
9. *Journal of Biological Chemistry.*
10. *Zeitschrift für anorganische und allgemeine Chemie.*
11. *Annales de chimie.*
12. *Zeitschrift für physikalische Chemie.*
13. *Journal of Chemical Education.*
14. *The Analyst.*
15. *Industrial and Engineering Chemistry, Analytical Edition.*
16. *Annalen der Chemie.*
17. *Transactions of the Electrochemical Society.*
18. *Bulletin de la société chimique de France.*
19. *Transactions of the American Institute of Chemical Engineers.*
20. *Helvetica Chimica Acta.*

(Consult "List of Periodicals" abstracted by *Chemical Abstracts,* along with a current issue of the periodical assigned.)

Part 3. In this part the periodicals required are first limited to some more or less specialized field of chemistry, such as organic. Then, if desired, they may be further limited by designating some

[1] Only those available to the student should be assigned.

country or language. A typical assignment would then read, "Supply the information indicated for two important German journals publishing articles on organic chemistry."

1. Electrochemistry.
2. Photography.
3. Quantitative analysis.
4. Mineralogical chemistry.
5. Plant equipment.
6. Organic chemistry.
7. General biological chemistry.
8. Rubber.
9. Cement.
10. Dyes.
11. Soaps.
12. Inorganic chemistry.
13. Metallurgy.
14. Foods.
15. Water.
16. Soils.
17. Fermentation industries.
18. Glass.
19. Wood products.
20. Petroleum.

(In order to decide on two important journals, the student may consult current issues of *Chemical Abstracts* and turn to the division indicated by the subject of his assignment. From several issues of the abstracting journal a list may be made of the various journals abstracted and the number of abstracts from each noted. The two journals having the largest number of abstracts may be taken for this report. Although this is a superficial procedure, it is sufficiently satisfactory for the requirements of the problem.)

Part 4. Articles in periodicals.

1. Oxidation of white oils.
2. Drying gel zeolites.
3. A new thiazine synthesis.
4. Ergosine and its salts.
5. Toxicology of rotenone.
6. Complex fluorides of gallium.
7. Dipole moments of hydrazides.
8. Control of rope in bread.
9. Test paper for aluminum.
10. Pyrolysis of ethane.
11. Opals.
12. The neutron.
13. Sulfite turpentine.
14. Synthesis of iretol.
15. Usnic acid.
16. Testing plastics.
17. Structure of osazones.
18. Vanadium catalysts.
19. Nitrogen afterglow.
20. Nature of lignin.

(Consult the subject indexes of *Chemical Abstracts.*)

Assignments for Library Problem 2

Part 1. Part one gives the name (or formula) for some chemical listed in the market reports. Either a date (year and month) may be specified, or the student may be permitted to select his own.

1. Citric acid.
2. Linseed oil.
3. Silver nitrate.
4. Chrome yellow.
5. Magnesite.
6. Amyl acetate.
7. Acetone.
8. Camphor.
9. Chloroform.
10. Sulfur.
11. Red lead.
12. Mercury.
13. Boric acid.
14. Bleaching powder.
15. Niter cake.
16. Iodine.
17. Bauxite.
18. Borax.
19. Soda ash.
20. Methanol.

(Consult market reports of journals on industrial chemistry.)

Part 2. Industrial equipment.

1. Ball mills.
2. Conveyors.
3. Emulsifiers.
4. Chemical stoneware.
5. Evaporators.
6. Autoclaves.
7. Thermocouples.
8. Muffle furnaces.
9. Colloid mills.
10. Drum driers.
11. Digestors.
12. Pulverizers.
13. Classifiers.
14. pH equipment.
15. Centrifugals.
16. Rotary filters.
17. Pyrometers.
18. Filter cloth.
19. Vertical mixers.
20. Molding presses.

(Consult current advertising in journals on industrial chemistry. Firms likely to advertise may be checked in a late edition of the "Chemical Engineering Catalog.")

Part 3. Book reviews in periodicals.

1. Colloid Chemistry (Thomas, A. W.).
2. The Farm Chemurgic (Hale, W. J.).
3. Crystal Chemistry (Stillwell, C. W.).
4. Anorganische Chemie (Ephraim, F.).
5. Prelude to Chemistry (Read, J.).
6. Nature of Physical Theory (Bridgman, R. W.).
7. Jöns Jacob Berzelius (Larsell, O.).
8. Ebulliometry (Swietoslawski, W.).
9. Flotation Plant Practice (Rabone, P.).
10. Research (Boyd, T. A.).
11. Thermodynamics (Fermi, E.).
12. Latex in Industry (Noble, R. J.).
13. Chemistry of Organic Compounds (Conant, J. B.).
14. Chemistry of the Sterids (Sobotka, H.).
15. Optical Rotatory Power (Lowry, T. M.).
16. Kinetic Theory of Gases (Loeb, L. B.).
17. Photoelements and Their Application (Lange, B.).
18. Handbook of Colorimetry (Hardy, A. C.).
19. Technical Gas Analysis (Lunge-Ambler).
20. Soybean Processing (Horvath, A. A.).

(Consult author indexes of *Technical Book Review Index*, or periodicals likely to contain such reviews.)

Part 4. In this part the student may be permitted to find an article of personal interest, or assignments may be used, such as those given in Problem 1, Part 4.[1]

(To find a specific assignment, consult the author or subject indexes of *Chemical Abstracts*, or those of appropriate original-source periodicals.)

Assignments for Library Problem 3

Part 1. In part one the assignment may be made from one or more of the lists of publications issued by the several departments of the federal government. In many cases the title of the source and the subject of the publication will be the same. In many others the subject is general in nature, and the publication itself consists of various separate parts having their specific titles. The following list is representative for publications from several of the bureaus of the government.

1. Dry cells.
2. Pyrometry.
3. Fuel briquetting.
4. Coal-dust explosions.
5. Food preservatives.
6. Sucrose in grapes.
7. Rare elements in the soil.
8. Surface waters of Indiana.
9. Analysis of silicate rocks.
10. Disposal of industrial wastes.
11. Polarimetry.
12. Calorimeters.
13. Analysis of coal and coke.
14. Titaniferous iron ores.
15. Sugar beets.
16. Soil solutions.
17. Data of geochemistry.
18. Constitution of natural silicates.
19. Cyanide fumigation.
20. Air in railway tunnels.

(Consult lists of publications of the appropriate bureaus.)

Part 2. Statistics of production and matters of technology (compiled for 1937).

1. Gold.
2. Phosphate rock.
3. Anthracite.
4. Iodine.
5. Silver.
6. Feldspar.
7. Carbon black.
8. Lignite.
9. Petroleum.
10. Asphalt.
11. Marble.
12. Sulfur.
13. Mercury.
14. Pyrites.
15. Bromine.
16. Lead pigments.
17. Kaolin.
18. Fluorspar.
19. Chromite.
20. Molybdenum.

[1] For the abstract the general form followed in *Chemical Abstracts* is desirable, but a beginning student can hardly be expected to conform closely to all the rules and regulations given in the pamphlet, "Directions for Assistant Editors and Abstractors of Chemical Abstracts." Only an experienced abstractor can meet these requirements of content, style, and form.

(Consult the "Minerals Yearbook," issued by the Bureau of Mines, back to 1931. Previous to this date, "Mineral Resources of the United States" contained this kind of data. It was issued by the Geological Survey from 1867 to 1923, and subsequently by the Bureau of Mines to 1932. Also see *Mineral Industry*.)

Part 3. Information on foreign chemical activities.[1]

1. Bulgaria.
2. France.
3. Lithuania.
4. Rumania.
5. Sweden.
6. Russia.
7. Cuba.
8. Canada.
9. Guatemala.
10. Mexico.
11. Argentina.
12. Bolivia.
13. Chile.
14. Peru.
15. China.
16. Philippines.
17. Turkey.
18. Egypt.
19. Australia.
20. Union of South Africa.

(Consult "World Chemical Developments" from the Bureau of Foreign and Domestic Commerce.)

Part 4. Imports or exports.[2]

Imports	Exports
1. Oleo stearin.	11. Vinegar.
2. Cinchona bark.	12. Rubber scrap.
3. Petroleum.	13. Peppermint oil.
4. China clay.	14. Coke.
5. Cut diamonds.	15. Lime.
6. Zirconium ore.	16. Steel wool.
7. Type metal.	17. Sulfur.
8. Synthetic menthol.	18. Tungsten metal.
9. Trichlorethylene.	19. Copper sulfate.
10. Chalk.	20. Flavoring extracts.

(Consult reports of Bureau of Foreign and Domestic Commerce and of the Tariff Commission.)

Part 5. Biennial (intercensal) reports.[3]

1. Aqua ammonia.
2. Calcium carbide.
3. Sodium iodide.
4. Silver nitrate.
5. Chrome alum.
6. Oxygen.
7. Linseed oil.
8. Soda ash.
9. Glycerol.
10. Acetone.
11. Methyl alcohol.
12. Water glass.
13. Tallow.
14. Gold leaf.
15. Ethyl ether.
16. Turpentine.
17. Hydrogen peroxide.
18. Salt cake.
19. Chlorine.
20. Charcoal.

[1] These assignments may be restricted to specific items, such as alcohol in Brazil.

[2] The assignments were taken from 1937 reports.

[3] A definite year (odd number) may be specified.

(Consult "Biennial Census of Manufactures" for the appropriate year. Also see annual report of the Tariff Commission for synthetic organic chemicals in the U. S.)

Part 6. Decennial (main) census reports.

1. Nitric acid, Illinois.
2. Cottonseed oil, Louisiana.
3. Mixed acids, Missouri.
4. Superphosphates, Georgia.
5. Rayon, Virginia.
6. Patent medicines, Indiana.
7. Petroleum refining, Wyoming.
8. Printing ink, Michigan.
9. Salt, West Virginia.
10. Blast-furnace iron, Alabama.
11. Hydrogen peroxide, New York.
12. Soap, Ohio.
13. Sulfuric acid, Tennessee.
14. Spirit varnish, Kentucky.
15. Explosives, Pennsylvania.
16. Perfumes, Wisconsin.
17. Glue, California.
18. Cleaning compounds, Oregon.
19. Beet sugar, Utah.
20. Corn products, Iowa.

(Consult the latest general census report.)

Assignments for Library Problem 4

Part 1. Part one is designed to acquaint the student with the information relating to patents which is contained in abstracting journals. The date of issue has been omitted in order to give more experience in finding the abstract. The patents listed were issued fairly recently.

1. Rubber hydrohalides.
2. Glass-to-metal seal.
3. Phthalonitrile.
4. Hardening photographic emulsions.
5. Columbium alloys.
6. Invertase from yeast.
7. Floating soap.
8. Haircloth.
9. Wool substitutes.
10. Synthetic hydrocarbon oils.
11. Firelighters.
12. Mullite-corundum refractory.
13. 22,23-Dihydroergosterol.
14. Solubilizing phosphates.
15. Ship's sewage disposal.
16. Molding artificial horn.
17. Olefin chlorohydrins.
18. Boron carbide.
19. Edible hydrogenated glyceride oils.
20. Photoelectric gloss meter.

(Consult subject indexes of *Chemical Abstracts.*)

Part 2. Patent numbers are included for some of the most important industrial countries. More than one answer may be found when a continuous numbering system is not used.

1. Canadian	347,320	4. D.R.P.[1]	605,150
2. Danish	47,000	5. Hungarian	110,825
3. Norwegian	54,050	6. Belgian	405,240

[1] Deutsches Reichspatent.

7. Russian	35,185	14. Austrian	142,401
8. U. S.	2,024,240	15. French	771,125
9. Swedish	82,000	16. Swiss	169,700
10. British	451,000	17. U. S.	1,980,000
11. French	808,310	18. Japanese	110,101
12. British	451,000	19. British	445,190
13. Dutch	33,929	20. Australian	21,300

(Consult patent-number indexes of *Chemical Abstracts.*)

Part 3. For this part the student should select from an abstracting journal, or other suitable source, the subject or title of a U. S. chemical patent in which he is interested. Having obtained the necessary information, he should then send to the U. S. Patent Office for a copy of the patent specifications (see p. 61 for procedure). From this document and from the abstracts found in *Chemical Abstracts* and the *Official Gazette* of the U. S. Patent Office the information required for the problem may be found.

Assignments for Library Problem 5

The assignments for this problem are designed to give experience in the use of several of the smaller collections of physical constants, such as Lange's "Handbook of Chemistry," Hodgman's "Chemical Tables," and Perry's "Chemical Engineers' Handbook." In parts three, four, and five a check mark may be placed at the value that is to be found, in case not all those included in the blank page apply to the assignment made.

Although only names of substances have been given in the lists, in making assignments one might equally well give either names or formulas, provided the student has had sufficient training to enable him to determine the name for a given formula.

Part 1. Constants for organic compounds.

1. Acenaphthene.
2. Eicosane (n).
3. Butyl acetate (n).
4. Melene.
5. Ceryl alcohol.
6. Asparagin.
7. Indene.
8. Benzamide.
9. Limonene (d).
10. Chloral.
11. Acrylic acid.
12. Heptine-1.
13. Diphenyl.
14. Stilbene.
15. Cadaverine.
16. Anethole.
17. Glyoxime.
18. Benzotrichloride.
19. Oxalyl chloride.
20. Furfural (2).

(Consult compilations such as those mentioned above.)

Part 2. Solubility data.

1. Erbium sulfate in water at 25°.
2. Helium in water at 50°.
3. Silver borate in water at 25°.
4. Lead malate in water at 18°.
5. Cerium glycolate in water at 20°.
6. Cobalt malate in water at 10°.
7. Ammonium oleate in acetone at 15°.
8. Aniline sulfate in water at 15°.
9. Silver phosphate in water at 20°.
10. Barium persulfate in water at 0°.
11. Cytisine in ether at 15°.
12. Selenous acid in water at 20°.
13. Narcotine in water at 20°.
14. Galactose in pyridine at 26°.
15. Cuminic acid in water at 25°.
16. Caffeine in water at 30°.
17. Rubidium fluoborate in water at 20°.
18. Rubidium iodate in water at 23°.
19. Lithium hippurate in water at 20°.
20. Calcium selenate in water at 20°.

(Consult Seidell's "Solubilities of Inorganic and Organic Compounds," or other similar works.)

Part 3. Constants for oils, fats, and waxes.

1. Clove oil.
2. Lemon oil.
3. Sassafras oil.
4. Wintergreen oil.
5. Geranium oil.
6. Arnica oil.
7. Onion oil.
8. Cod-liver oil.
9. Olive oil.
10. Corn oil.
11. Sesame oil.
12. Cottonseed oil.
13. Sunflower oil.
14. Poppy-seed oil.
15. Chicken fat.
16. Nutmeg butter.
17. Beeswax.
18. Mutton tallow.
19. Dog fat.
20. Wool fat.

(Consult small handbooks of physical constants.)

Part 4. Thermochemical data.

1. Sodium chloride.
2. Red brass.
3. Iodine pentoxide.
4. Asphalt.
5. Potassium cyanide.
6. Glycerol.
7. Boron oxide.
8. Carbon monoxide.
9. Silver nitrate.
10. Flint glass.
11. Ammonium nitrate.
12. Peat.
13. Cupric chloride.
14. Vulcanite.
15. Nitric acid.
16. Naphthalene.
17. Calcium oxide.
18. Tantalum.
19. Lithium oxide.
20. Hardwood.

(Consult small handbooks of physical constants.)

Part 5. Data in property-substance tables.

Melting Point	Boiling Point	Refractive Index[1]	Density
− 70°C.	− 95°C.	1.4110	0.750
0°	53°	1.4500	1.150
101°	115°	1.4801	1.340
310°	191°	1.5300	2.110
500°	600°	1.611	3.022

[1] Liquids.

(Consult property-substance tables in "International Critical Tables.")

Part 6. For these assignments one goes from specific gravity to percentage composition, and from percentage to degrees Baumé.

1.	1.129	$AlCl_3$	18/4°	11.	1.177	$Al_2(SO_4)_3$	15/4°
2.	1.040	NH_4Cl	20/4°	12.	1.337	H_3AsO_4	15/4°
3.	1.253	$BaCl_2$	20/4°	13.	1.337	$CaCl_2$	20/4°
4.	1.075	$Cr_2(SO_4)_3$	15/4°	14.	1.107	$Cu(NO_3)_2$	20/4°
5.	1.418	$FeCl_3$	20/4°	15.	1.017	HCOOH	20/4°
6.	1.129	HCl	20/4°	16.	1.012	H_2SiF_6	17.5°
7.	1.081	$MgCl_2$	20/4°	17.	1.109	$NiSO_4$	18/4°
8.	1.140	HNO_3	20/4°	18.	1.379	H_3PO_4	20/4°
9.	1.107	KBr	20/4°	19.	1.073	KOH	15/4°
10.	1.019	Na_2CO_3	20/4°	20.	1.153	NaOH	20/4°

(Consult small handbooks of physical constants.)

Part 7. General data for chemical engineering.

1. Centrifugal pumps.
2. Gaseous electrothermics.
3. Conveyors for solids.
4. Electrowinning-fused electrolytes.
5. Whizzer air separation.
6. Hydrogen-ion controllers.
7. Disk and cone crushers.
8. Screen efficiency and capacity.
9. Intermittent vacuum filters.
10. Condenser calculations.
11. Electrolytic refining.
12. High-pressure equipment.
13. Milling paints and pastes.
14. Tank crystallization.
15. Crystal growth.
16. Attrition mills.
17. Gravitational separation of dusts.
18. Flotation.
19. Petroleum distillation.
20. Multiple-effect evaporation.

(Consult Perry, "Chemical Engineers' Handbook.")

Assignments for Library Problem 6

In contrast to Problem 5, which dealt with the data to be found in the smaller collections of physical constants, this problem is designed for the use of the comprehensive compilations of such information. The most generally useful sources are the American "International Critical Tables," the German "Physikalisch-chemische Tabellen," and the French "Tables Annuelles. . . . "

Part 1. "Key formulas" used in arranging "I.C.T." data.

1. $SO_3.SeCl_4$.
2.
3. $SnCl_4.2NOCl$.
4. $Tl_2H_2P_2O_7$.
5. $Hg(C_2H_5S)_2$.
6. Ag_2HPO_4.
7. $PtPbBr_6$.
8. $Fe_2(CO)_9$.
9. SO_2OHCl.
10. $SiCl_3.SH$.
11. $SnBr(C_2H_5)_3$.
12. $Zn_3As_2O_8$.
13. $CuC_2O_4.2NH_3$.
14. [
15. NH_4MnO_4.
16. $(NH_4)_2CrSO_7$.
17. $(NH_4)_2SeBr_6$.
18. $(NH_4)_2SiF_6$.
19. $PbHAsO_4$.
20. $Cd(IO_3)_2.4NH_3$.

(Consult "International Critical Tables," I, 96.)

Part 2. General information in "International Critical Tables."

1. Commercial explosives.
2. Absorption spectra of dyes.
3. Dielectric properties.
4. Soap solutions.
5. Heat capacity.
6. Osmotic pressure.
7. Density.
8. Air conditioning.
9. Artificial plastics.
10. Radioactivity.
11. Viscosity of pure liquids.
12. Electrolytic electromotive force.
13. Electrical conductivity.
14. Spectroscopy.
15. Surface tension.
16. Cryoscopic data.
17. Phase equilibrium data (liquids).
18. Metals and alloys.
19. Dental cements.
20. Crystal structure.

(Consult I.C.T., Vol. I–VII.)

Part 3. Specific I.C.T. data.

1. Producing low temperatures.
2. Radioactivity of greenstone.
3. Explosive limits of air and ethane.
4. Density: soln. of $NaC_2Cl_3O_2$.
5. Miscibility: water, acetone, sugars.
6. Osmotic pressure: gelatin.
7. Heat capacity: Ni, Te alloy.
8. Persistent lines: indium.
9. Transference numbers: $SrCl_2$.
10. Refractivity: quinic acid soln.
11. X-ray diffraction for NaN_3.
12. Properties of borate glasses.
13. Equilibrium diagram: V, Si alloy.
14. Vapor pressure: phenol.
15. Solubility: LiI in ethanol.
16. Surface tension: bromobenzene.
17. Heat of combustion: caproic acid.
18. Bromine overvoltage.
19. Resistivity: Cu, P alloy.
20. Optical rotation: dizingiberene.

(Consult I.C.T. index for the kind of data sought and then search the appropriate section for the specific facts.)

Part 4a. Location of collected data.

1. Isotopes.
2. Compressibility of liquids.
3. Viscosity of gases.
4. Diffusion coefficients of
5. Density of chemical elements.
6. Specific gravity of molten salts.
7. Solidification curves of alloys.
8. Mutual solubility of liquids.

9. Crystal structure.
10. Optical rotation of organic substances.
11. Refractive index of inorganic liquids.
12. Dielectric constants.
13. Solubility products.
14. Electrical conductivity of aq. solns.
15. Electrolytic dissociation constants.
16. Specific heat of aq. solns. of gases.
17. Thermal conductivity of metals.
18. Specific volume of water vapor.
19. Heat of dilution.
20. Heat of transformation of allotropic substances.

(Consult indexes to the Landolt-Börnstein set.)

Part 4b. Location of specific data.

1. Heat of combustion: diphenyl.
2. Heat of dilution: tetramethyl ammonium chloride.
3. Heat of formation: ozone.
4. Boiling-point elevation: $K_2C_2O_4$.
5. Osmotic pressure: lactose in water.
6. Vapor pressure: NH_4N_3 in NH_3.
7. Thermal conductivity: glass wool.
8. Specific heat: phosgene.
9. Magnetic susceptibility: CuCl.
10. Coefficient of cubical expansion: anthracene.
11. Activity coefficient: CsOH.
12. Electrolytic-dissociation constant: suberic acid.
13. Electrical conductivity: KCl in ICl.
14. Transport numbers: Ag_2HgI_4.
15. Molar potential: $IrCl_6'''/IrCl_4''$
16. E.m.f.: $Co/CoCl_2//HgCl/Hg$.
17. Solubility: air in HNO_3.
18. Compressibility: argon.
19. Light absorption: $NiCl_2$ (infrared).
20. Crystal structure: LaF_3.

(Consult Landolt-Börnstein set for location of kind of data sought and then search the section for specific facts.)

Part 5. Data recently compiled.[1]

1. Compressibility: Re.
2. Thermal expansion: Brucite.
3. Density: Fe_2P.
4. Viscosity: $C_2F_2Cl_4$.
5. Surface tension: $GeBr_4$.
6. Heat conductance: SO_2.
7. Specific heat: Ga.
8. Free energy: Li_2SO_4.
9. Activity: Ag_2O.
10. Magnetic susceptibility: $InBr_3$.
11. Physical constants: $C_{43}H_{74}O_3$.
12. Crystallography: Scawtite.
13. Adsorption: H by Cu.
14. Electrical conductivity: alkaline thiocyanates.
15. Heat of solution: Li in NH_3, liq.
16. Vapor pressure: 1-pentanol.
17. Solubility: CdI_2 in ether.
18. Dielectric constant: aniline.
19. Heat of fusion: $WOCl_4$.
20. Heat of vaporization: $Ga(CH_3)_3$.

(Consult the French "Tables Annuelles . . . ")

[1] These assignments are for the volumes for 1930 or 1931–1934.

Assignments for Library Problem 7

Problem 7, devoted to more or less general information in organic chemistry, is designed to bring the student into contact with various comprehensive reference works in the field (except Beilstein's, for which see Problem 8).

Part 1. This part illustrates the difference in treatment accorded a given compound in a single-volume work (Whitmore) and in more comprehensive works.

1. Morpholine.
2. Isatin.
3. Menthene.
4. Azobenzene.
5. Methylal.
6. Phosgene.
7. Isobutylene.
8. Safrole.
9. Arginine.
10. Diphenyl.
11. Melamine.
12. Tetraldan.
13. Quinic acid.
14. Isoprene.
15. Morin.
16. Capric acid.
17. Phorone.
18. Cineole.
19. Borneol.
20. Sabinol.

(Consult the works specified.)

Part 2. Naming compounds.

1.
2. C_3H_5NCS.
3. $NH_2.C_{10}H_6.OH$.
4. $NH_2.C_6H_4.OCH_3$.
5. $C_6H_2Br(NO_2)_2COOH$.
6. $Cl.C_6H_3.(OH)_2$.
7. $CH_2Br.CHBr.COOH$.
8. $(CH_3)_2C:NOH$.
9. $NH_2.C_6H_4.CHO$.
10.
11. $C_6H_5.SO_2.NH_2$.
12. $CH_3.CH:C:CH_2$.
13. $C_6H_5.CCl:CH_2$.
14. $CH_3.CCl_2.NO$.
15. $CH_2:CH.CHO$.
16. $C_6H_5.CO.CH_2.NH_2$.
17. $(CH_3)_2.CH.(CH_2)_2.SH$.
18. $CH_3.CO.NHBr$.
19. $CH_3.CO.NHCl$.
20. $CH_3.C_5H_3N.C_2H_5$.

(Consult organic texts dealing with nomenclature.)

Part 3a. Unusual or new compounds[1] (empirical formulas).

6. $C_{39}H_{39}As_3Cl_3Cu_2$.
7. $C_{37}H_{40}N_4O_7Zn$.
8. $C_{60}H_{33}I_4N_5$.
9. $C_{51}H_{30}AlN_3O_3$.
10. $C_{48}H_{40}As_2O_4S$.
11. $C_{44}H_{26}Fe_2N_6NiO_8$.
12. $C_{41}H_{32}NO_8P$.
13. $C_{38}H_{78}PbS_2$.
14. $C_{35}H_{32}ClN_3O_7$.
15. $C_{54}H_{93}O_3P$.
16. $C_{50}H_{45}N_5O_{10}S_3$.
17. $C_{48}H_{36}CoN_9$.
18. $C_{43}H_{37}I_2N_3S_3$.
19. $C_{41}H_{33}CuN_7O_4$.
20. $C_{38}H_{34}CuN_4O_3$.

[1] The assignments are all for 1938.

(Consult formula indexes of *Chemical Abstracts.*)

Part 3b. Named processes.

1. Aldol condensation
2. Benzidine rearrangement.
3. Buchner-Curtius reaction.
4. Doctor process.
5. Fehling test.
6. Frasch process.
7. Grignard reaction.
8. Hinsberg separation.
9. Kjeldahl method.
10. Meyer polymerization.
11. Purdie methylation.
12. Wohl degradation.
13. Beilstein test.
14. Berthelot synthesis.
15. Clemmenson reduction.
16. Dumas determination.
17. Fittig-Erdman synthesis.
18. Gattermann reaction.
19. Hofmann rearrangement.
20. Lieben reaction.

(Consult texts on organic chemistry.)

Part 3c. General discussions of specific subjects.

1. Theory of strain.
2. Organometallic compounds.
3. Unsaturation and conjugation.
4. Molecular rearrangements.
5. Natural amino acids.
6. Alkaloids.
7. Carotenoids.
8. Structure of carbohydrates.
9. Rotatory dispersion.
10. Substituted sugars.
11. Physical properties of organic compounds.
12. Resonance and organic compounds.
13. Stereoisomerism.
14. Free radicals.
15. Open-chain nitrogen compounds.
16. Chemical reactivity.
17. Chemistry of pyrimidines.
18. Anthocyanins.
19. Sterols.
20. Cellulose.

(Consult the more comprehensive works in organic chemistry.)

Part 3d. Organic reactions.

1. Neopentane + chlorine.
2. Alkyl halides + aluminum chloride.
3. Alcohols + thionyl chloride.
4. Methyl amine + chlorine and alkali.
5. Schiff's bases + acids.
6. Calcium propionate + destructive distillation.
7. Acrylic acid + concentrated alkali.
8. Acyl halides + Grignard reagents.
9. Ethylene oxide + magnesium chloride.
10. Chloroacetic acid + lime.
11. Oxalic acid + electrolytic reduction.
12. Primary amines + bromine and potassium hydroxide.
13. Ethyl carbonate + Grignard reagents.
14. Thiourea + hydrogen peroxide.

15. Carbon disulfide + ammonia.
16. Proteins + nitric acid.
17. Benzene + hydriodic acid.
18. Phenol + formaldehyde.
19. Chloranil + alcoholic ammonia.
20. Pyridine + nitrogen dioxide.

(Consult texts and reference works on organic chemistry.)

Assignments for Library Problem 8

Parts 1–2. The aim in parts 1 and 2 of this problem is to use the sources which are intended to provide references to a complete survey of the chemistry of the given compound. Although the name of a compound is given here,[1] with the formula to be supplied, the assignment might be reversed. The references should be copied as found, those in the formula indexes being accompanied by a statement to indicate the meaning of each item.

1. Phenolphthaleindiacetate.
2. 2,4,6-Trinitrohydrazobenzene.
3. Methylguanidine.
4. 3-Aminophenanthrene.
5. dl-Methylethylacetic acid.
6. Methanedisulfonic acid.
7. Chloromethylisocyanate.
8. Anthraquinonemonoxime.
9. m-Tolylacetaldehyde.
10. Phenyldichlorostibine.
11. 1,3-Dimethylbarbituric acid.
12. Quinoline-2-carboxylic acid.
13. 2,3-Dichloro-1,4-naphthoquinone.
14. Hydroxyhydroquinonetriacetate.
15. 1-Butene-1,1,3,3-tetracarboxylic acid.
16. Isoamyloleate.
17. Methylphenylbenzylcarbinol.
18. Methylisobutylaniline.
19. 2-Aminothioanisol.
20. 4,4′-Dimethylazoxybenzene.

(Consult the works specified.)

Part 3a. Named organic radicals.

1. Acetonyl.
2. 3-Butenyl.
3. Cinnamal.
4. Duryl.
5. Furyl.
6. Arsono.
7. 1-Isopentenyl.
8. Anisyl.
9. Leucyl.
10. α-Mesityl.
11. Glycyl.
12. Cyclobutyl.
13. Caprylyl.
14. Hydrazi.
15. Phosphono.
16. Benzoxy.
17. Fluorylidene.
18. Isoamylidene.
19. Xyloyl.
20. Indyl.

(Consult 3rd Decennial Index of *Chemical Abstracts*.)

[1] It is desirable to select compounds somewhat rare to avoid large numbers of references.

Part 3b. Organic ring complexes.

1. Arsenole.
2. Decacyclene.
3. Anthradiquinoline.
4. Benzofluorindine.
5. Chelidonine.
6. Flavophene.
7. Coproporphyrin.
8. Quinoquinolizine.
9. Anthranthrene.
10. Dicycloheptapyrazine.
11. Tetrazole.
12. Selenoxanthene.
13. Flavanthrene.
14. Dimeric anilide.
15. Furobibenzopyran.
16. Anthrapyrrole.
17. Cerodithiene.
18. Thionaphthenindole.
19. Fluorubine.
20. Acenaphthazine.

(Consult 3rd Decennial Index of *Chemical Abstracts*, or the annual indexes.)

Assignments for Library Problem 9

Part 1. This part is similar to Problem 8 for organic chemistry.

1. Cesium sulfide.
2. Beryllium carbide.
3. Boron nitride.
4. Nitrosyl bromide.
5. Boron trifluoride.
6. Rubidium iodide.
7. Gallium triiodide.
8. Chlorine dioxide.
9. Zinc carbonate.
10. Barium fluosilicate.
11. Barium peroxide.
12. Bismuth oxychloride.
13. Bromic acid.
14. Cadmium telluride.
15. Lithium azide.
16. Sodium perborate.
17. Lead molybdate.
18. Sodium amide.
19. Cadmium iodide.
20. Tetrammino-diaquo-cobalti chloride.

(Consult treatises on inorganic chemistry.)

Part 2. Known inorganic compounds.

1. Ag, Fe, O.
2. Al, Cl, H, N.
3. B, H, N, Na.
4. Ca, Cl, H, O, P.
5. Cd, F, Ga, H, O.
6. Cl, H, N, O, Ru.
7. Cl, H, N, Pd, Pt.
8. Co, F, Ga, H, O.
9. Cu, H, N, O, Sb.
10. Fe, H, O, Pb, S.
11. H, K, N, O, S.
12. Al, Ca, Fe, O.
13. Be, O, Si, Zn.
14. Br, H, N, Ru.
15. Cb, H, K, O, S.
16. Cl, Co, H, N, O, S.
17. Cl, K, O, Re.
18. Cr, K, O, Se.
19. F, H, N, Ni, O, P.
20. N, Nd, O, Zn.

(Consult formula indexes for inorganic compounds.)

Assignments for Library Problem 10

Part 1. Qualitative tests.[1]

1. Cd.	6. Se.	11. Tl.	16. B.
2. Mn.	7. Pt.	12. S.	17. Co.
3. Sr.	8. Pb.	13. V.	18. W.
4. Fe.	9. Cr.	14. Bi.	19. Ta.
5. Li.	10. H.	15. C.	20. Ni.

(Consult general works on qualitative analysis.)

Part 2. General quantitative methods.

1. Al.	6. Sb.	11. As.	16. Be.
2. Ca.	7. Cu.	12. Ba.	17. I.
3. K.	8. Mn.	13. Hg.	18. Mo.
4. P.	9. N.	14. Mg.	19. Au.
5. Si.	10. Ag.	15. Sn.	20. Ce.

(Consult general works on quantitative analysis.)

Part 3. Measurement of a given constituent in a given sample.

1. Bromine in sea water.	11. Manganese in iron ore.
2. Arsenic in foods.	12. Phosphorus in plants.
3. Selenium in soils.	13. Nicotine in tobacco.
4. Ethanol in liquors.	14. Vanadium in steel.
5. Nitrogen in coal.	15. Calcium in milk.
6. Titanium in steel.	16. Potassium in fertilizers.
7. Manganese in rocks.	17. Hydrogen in organic compounds.
8. Carbon dioxide in air.	18. Iodine number of oils.
9. Carotene in butter.	19. Nickel in cast iron.
10. Volatile matter in coal.	20. Marihuana in cigarettes.

(Consult works on applied analysis.)

Part 4. Complete analyses of commercial materials.

1. Milk.	8. Cocoa.	15. Water.
2. Steel.	9. Cement.	16. Rocks.
3. Explosives.	10. Glass.	17. Waxes.
4. Brass.	11. Al alloys.	18. Coffee.
5. Pepper.	12. NaOH.	19. HNO_3.
6. Dyes.	13. Soils.	20. Rubber.
7. Wood.	14. Oils.	

(Consult works on applied analysis.)

[1] Either an organic or inorganic constituent may be designated, although the list given is limited to chemical elements. Space is provided for only two characteristic reactions and two methods of detection, but these might be extended.

Assignments for Library Problem 11

This problem deals with a variety of items of more or less general interest in industrial chemistry and chemical engineering.

Part 1. Books on industrial chemical subjects.

1. Acid-resisting materials.
2. Chemical apparatus.
3. Bleaching.
4. Cement.
5. Protective coatings.
6. Cosmetics.
7. Filter presses.
8. Latex.
9. Metallic compounds.
10. Plant management.
11. Aluminum paint.
12. Bearing metals.
13. Bronze.
14. Cheese.
15. Clay.
16. Detergents.
17. Electrometallurgy.
18. Gas reactions.
19. Ore deposits.
20. Shale oil.

(Consult catalogues and lists of books.)

Part 2. Commercial products having brand names.

1. Alunaze.
2. Borvac.
3. Carbodite.
4. Dendrol.
5. Efflofyx.
6. Flintox.
7. Gildura.
8. Hoofol.
9. Infilco.
10. Joanite.
11. Kelene.
12. Lewrite.
13. Mellose.
14. Niagratite.
15. Oxynone.
16. Pipsolene.
17. Quinotol.
18. Rubaline.
19. Shinglene.
20. Tragasol.

(Consult works listed in Chap. IX, 2.)

Part 3. Firms manufacturing chemical equipment.

1. Gas absorbers.
2. Rubber-covered agitator.
3. Acid-resisting bronze.
4. Electrolytic cells.
5. Portable compressors.
6. Gyratory crushers.
7. Stoneware.
8. Multiple-disk filters.
9. Gas producers.
10. Rod mills.
11. Diaphragm pumps.
12. Drum washing machines
13. Furnace blocks.
14. Lead carboys.
15. Chlorinators.
16. Gas mixing controls.
17. Hearth driers.
18. Silver kettles.
19. Acid sludge separators.
20. Denitrating towers.

(Consult works listed in Chap. IX, 2.)

Part 4. Scientific names of commercial chemicals.

1. Cleve's acid.
2. Chrome yellow.
3. Sal ammoniac.
4. Baking soda.
5. Brimstone.
6. Calomel.

7. Caustic soda.
8. Lime.
9. Marsh gas.
10. Corrosive sublimate.
11. Cream of tartar.
12. Venetian red.
13. Epsom salt.
14. Paris green.
15. American vermilion.
16. Borax.
17. Plaster of Paris.
18. Potash.
19. Saltpeter.
20. Blue vitriol.

(Consult dictionaries, encyclopedias, and works listed in Chap. IX, 2.)

Part 5. Cost of commercial laboratory equipment.

1. Keyboard balance.
2. Ball mill.
3. Calorimeter (coal).
4. Silica crucibles.
5. Chromel gauze.
6. Motor generator.
7. Viscosimeter.
8. Chemical microscope.
9. Spectrophotometer.
10. Pyrometer.
11. Certified buret.
12. Vacuum oven.
13. Supercentrifuge.
14. Hydrometer set.
15. Platinum dishes.
16. Beckman thermometer.
17. Vacuum pump.
18. Muffle furnace.
19. Water still.
20. Electrodeposition apparatus.

(Consult catalogues of chemical supply houses.)

Part 6. Bibliographies on commercial subjects.

1. Waterproofing cement.
2. Turpentine.
3. Soybean oil.
4. Borax.
5. Corundum.
6. Ethylene.
7. Furfural.
8. Lacquers.
9. Nitrocellulose.
10. Maltose.
11. Tantalum.
12. Acetophenone.
13. Bauxite.
14. Chaulmoogra oil.
15. Dextrin.
16. Dehydrated foods.
17. Indigo.
18. Mineral paints.
19. Pectin.
20. Fibrin.

(Consult West and Berolzheimer's "Bibliography of Bibliographies.")

Part 7. Important dealers in industrial chemicals.

1. Amygdalic acid.
2. Caffeine.
3. Ferric citrate.
4. Hydroquinone
5. Lanolin.
6. Mercury.
7. Corn oil.
8. Pyridine.
9. Selenium.
10. Ultramarines.
11. Benzoyl chloride.
12. Diphenyl.
13. Glycine.
14. Inhibitors (pickling).
15. Pebble lime.
16. Nicotine sulfate.
17. Phenolbarbital.
18. Resorcinol.
19. Tetrachlorethane.
20. Xylenols.

(Consult works listed in Chap. IX, 2.)

Part 8. Location of chemical manufacturers.

1. Alabama.
2. Connecticut.
3. Indiana.
4. Maine.
5. Grand Rapids, Mich.
6. St. Louis, Mo.
7. New Hampshire.
8. N. Carolina.
9. Oregon.
10. Wisconsin.
11. San Francisco
12. Florida.
13. Idaho.
14. Kansas.
15. Minneapolis, Minn.
16. Trenton, N. J.
17. Albany, N. Y.
18. Akron, O.
19. Oklahoma.
20. Easton, Pa.

(Consult works listed in Chap. IX, 2.)

Part 9. Commercial methods of manufacture.

1. Aluminum.
2. Furfural.
3. Cupric sulfate.
4. Ethylene glycol.
5. Calomel.
6. Catechol.
7. Dry ice.
8. Acetaldehyde.
9. Lithium chloride.
10. Cyclopropane.
11. Bromine.
12. Quinone.
13. Paris green.
14. Isopropyl alcohol.
15. Caustic soda.
16. Nitrocellulose.
17. Soda ash.
18. Tetraethyl lead.
19. Perchloric acid.
20. Phthalic anhydride.

(Consult works on industrial chemistry.)

Part 10. History of chemical industries.

1. Aluminum alloys.
2. Petroleum cracking.
3. Rayon industry.
4. Graphitic lubricants.
5. Farm-waste insulation.
6. Calcium cyanamide.
7. Gunpowder.
8. Artificial leather.
9. Acid-resistant steels.
10. Cellophane.
11. Ductile tungsten.
12. Synthetic perfumes.
13. Insulin.
14. High explosives.
15. Radium production.
16. Zeolite water softening.
17. Carborundum.
18. Automobile lacquers.
19. High-octane gasoline.
20. "Freon" refrigerant.

(Consult abstracting journals and periodicals on industrial chemistry.)

Assignments for Library Problem 12

Additional items of commercial interest are included.

Part 1. Annual reviews of industrial developments.[1]

1. Fuels.
2. Tar products.
3. Textile fibers.
4. Acids.
5. Cement.
6. Nonferrous metals.

[1] The assignments are for 1938.

7. Oils, fats, and waxes.
8. Rubber.
9. Foods.
10. Fermentation industry.
11. Mineral oils.
12. Dye intermediates.
13. Pulp and paper.
14. Glass.
15. Steel.
16. Fertilizers.
17. Plastics.
18. Fine chemicals.
19. Explosives.
20. Electrochemical industry.

(Consult review serials.)

Part 2. Sources of raw materials.

1. Argols.
2. Bentonite.
3. Divi-divi.
4. Lime Vienna.
5. Mineral rubber.
6. Pitch coke.
7. Saponin.
8. Colloidal sulfur.
9. Turmeric.
10. Venice turpentine.
11. Bauxite.
12. Activated clay.
13. Hypernic.
14. Asbestos.
15. Madder.
16. Oiticica oil.
17. Rare metals.
18. Slate flour.
19. Mutton tallow.
20. Vermiculite.

(Consult works listed in Chap. IX, 2.)

Part 3. Composition of, and general information regarding, industrial products.

1. Cymbal brass.
2. Abrastol.
3. Chrysogen.
4. Pyroxylin.
5. Cairngorm.
6. Ichthyol.
7. Resistal.
8. Acridine.
9. Lithopone.
10. Brunswick green.
11. Celluloid.
12. Invar.
13. Shellac.
14. Agalite.
15. Isinglass.
16. Bengal lights.
17. Lava.
18. Aseptol.
19. Varnish removers.
20. Carmine.

(Consult dictionaries and encyclopedias.)

Part 4. Commercial grades of industrial materials.

1. Antimony metal.
2. Fluorspar.
3. Raw sulfur.
4. Acetamide.
5. Ammonium fluoride.
6. Carbon tetrachloride.
7. Ethyl ether.
8. Lead acetate.
9. Silver nitrate.
10. Sodium cyanide.
11. Cottonseed oil.
12. Carnauba wax.
13. Formic acid.
14. Isopropyl alcohol.
15. Bromine.
16. Chloroform.
17. Ferric chloride.
18. Potassium bichromate.
19. Sodium bicarbonate.
20. Zinc chloride.

(Consult works listed in Chap. IX, 2.)

Part 5. Commercial uses of chemicals.

1. Acetophenone.
2. Aluminum chloride.
3. Amyl butyrate.
4. Liquid ammonia.
5. Anthracene.
6. Arsenic.
7. Benzyl cyanide.
8. Borax.
9. Caramel.
10. Liquid chlorine.
11. Citral.
12. Copper nitrate.
13. Dichlorethylene.
14. Iron acetate.
15. Geraniol.
16. Lithopone.
17. Nicotine salts.
18. Niter cake.
19. Mustard oil.
20. Zinc chloride.

(Consult works listed in Chap. IX, 2.)

Part 6. Manufacturer's technical publications (industrial literature).

1. Electronic controls.
2. Gas compressors.
3. Liquid meters.
4. Whizzer air separators.
5. Tower packing.
6. Centrifúgal filters.
7. Activated alumina.
8. pH indicators.
9. Glass-lined equipment.
10. Poidometers.
11. Supercentrifuges.
12. Temperature measurement.
13. Duriron.
14. Pliolite.
15. Spectrographs.
16. Aluminum equipment.
17. Stainless-steel stills.
18. Dowtherm heating systems.
19. Vacuum evaporators.
20. Nitrating kettles.

(Consult works listed in Chap. IX, 2, or late issues of periodicals on industrial chemistry.)

Part 7. Miscellaneous industrial information.

1. Turpentine spirits.
2. Cutch.
3. Castor oil.
4. Acetylene.
5. Edible casein.
6. Chromic acid.
7. Amyl alcohol (n).
8. White arsenic.
9. Chlorosulfonic acid.
10. Bromine.
11. Acetic acid.
12. Nitrotoluene.
13. Frankfort black.
14. Acetone.
15. Hydrofluoric acid.
16. Ethanol.
17. Acetal.
18. Benzene.
19. Chloroform.
20. Acetylene tetrachloride

(Consult works listed in Chap. IX, 2.)

Part 8. Specifications.

1. Asphalt.
2. Fire clay.
3. Silver solder.
4. Ferro-silicon.
5. Ether for anesthesia.
6. Aviation gasoline.
7. Sulfuric acid.[1]
8. Lubricating oil.

[1] Analytical reagent quality.

9. Sulfur.
10. Soda ash.
11. Pig lead.
12. Portland cement.
13. Shellac varnish.
14. Sodium hydroxide.[1]
15. Chemical glassware.
16. Ni-Cr heating alloy.
17. Cane sugar.
18. Marine boiler steel.
19. Raw tung oil.
20. Soluble nitrocellulose.

[Consult "List of American Standards" (Am. Standard Assoc.); A.S.T.M. Standards; "Standards and Specifications" (*Nat. Bur. Standards Misc. Pub.* 79, 110, 120);[2] Federal Specifications, Price List 75; "Pharmacopoeia of the U. S."; Rosin, "Reagent Chemicals and Standards."]

Part 9. Chemically resistant materials.

1. Cl, liq.
2. HF.
3. H_2SO_4, conc.
4. NH_3, liq.
5. NaCl, aq.
6. NaOH, fused.
7. Diethyl ether.
8. Br.
9. KOH, aq.
10. $HClO_4$, 72%.
11. Hg.
12. $MgSO_4$, aq.
13. KNO_3, fused.
14. Carbon tetrachloride.
15. H_2O_2.
16. HCl, 35%.
17. H_3PO_4.
18. H_2SO_4, 20%.
19. Phenol, alc.
20. Ethanol.

(Consult works on chemical properties of materials; monographs on corrosion.)

Assignments for Library Problem 13[3]

This problem covers general items of interest for dyes.

1. Orange II.
2. Direct brown M.
3. Safranine.
4. Vat orange R.
5. Indigo vat pink.
6. Metanil yellow.
7. Ponceau 2R.
8. Chrysoidine Y.
9. Direct black EW.
10. Sulfur blue.
11. Amaranth.
12. Oil orange.
13. Cloth red 2B.
14. Direct brown 3GO.
15. Acid black 10B.
16. Wool green S.
17. Indigo.
18. Direct fast blue.
19. Victoria violet.
20. Amidonaphthol red G.

(Consult works likely to contain such information.)

[1] Analytical reagent quality.

[2] *Nat. Bur. Standards Misc. Pub.* 130 is the National Directory of Commodity Specifications.

[3] Various instructors in specialized fields of chemistry wish to have their students go into more detail than the rather general previous problems, such as Problems 7 and 8 in organic chemistry. Problem 13 is included as an example of one kind of specialized assignment in organic chemistry. Similar problems could be devised for other special subjects or broader fields, such as agricultural chemistry or biochemistry.

Assignments for Library Problem 14

Part 1. Common ores.

1. Al.
2. Cd.
3. Cu.
4. Pb.
5. Hg.
6. Sn.
7. V.
8. Sb.
9. Cr.
10. Au.
11. Mg.
12. Ni.
13. Zn.
14. Pt.
15. Bi.
16. Co.
17. Fe.
18. Mn
19. Ag.
20. Mo

(Consult general works on metallurgy; encyclopedias.)

Part 2. Methods of treating ores.

1. Sphalerite.
2. Cerargyrite.
3. Pyrolusite.
4. Siderite.
5. Chalcopyrite.
6. Bismuthinite.
7. Bauxite.
8. Cassiterite.
9. Cinnabar.
10. Magnesite.
11. Pyrite.
12. Smaltite.
13. Antimonite.
14. Cerussite.
15. Smithsonite.
16. Braunite.
17. Galena.
18. Malachite.
19. Chromite.
20. Stibnite.

(Consult works on general metallurgy.)

Part 3. Uses of metallurgical products (alloys).

1. Cu-Be.
2. German silver.
3. Dow metal.
4. Duriron.
5. Powdered Cu.
6. Illium.
7. Se steel.
8. Ni cast iron.
9. Nichrome.
10. Ni brasses.
11. Monel.
12. Krovan.
13. Silver solder.
14. Antimonial lead.
15. Nitrided steel.
16. Invar.
17. Ta carbide.
18. Wood's metal.
19. Stellite.
20. Rh plate.

(Consult metallurgical treatises; works listed in Chap. IX, 2; encyclopedias.)

Part 4. Books on metallurgical subjects.

1. Alloy steels.
2. Corrosion.
3. Electrometallurgy.
4. Molding.
5. Soldering.
6. X Rays.
7. Crystal structure.
8. Malleable iron.
9. Flotation.
10. Electroplating.
11. Bearing metals.
12. Fatigue.
13. Hardening.
14. Ore dressing.
15. Welding.
16. Coloring.
17. Tin.
18. Stamping.
19. Die casting.
20. Metallurgy (general).

(Consult Rimbach's book list.)

Part 5. Composition of alloys.

1. Cellini.
2. Dymal.
3. Alcumite.
4. Inconel.
5. Cupron.
6. Krovan.
7. Firex.
8. Normar.
9. Regal.
10. Teenax.
11. Dacar.
12. Halcut.
13. Pyrocast.
14. Hascrome.
15. Cimet.
16. Hobalite.
17. Nipegon.
18. Polaris.
19. Spartan.
20. Viking.

(Consult "Metals Handbook"; "I.C.T."; lists of alloys.)

Part 6. Equilibrium diagrams (alloys).

1. Na-Cd.
2. Ni-Sb.
3. Ce-Bi.
4. Zn-Sn-Bi.
5. Cu-Cr-Mo.
6. Cs-Hg.
7. Fe-Ce.
8. Be-Cu.
9. Ca-Pb.
10. Cd-Zn-Bi.
11. K-Tl.
12. Al-Co.
13. Mn-Au.
14. Al-Cu-Zn.
15. Ag-Au-Cu.
16. W-Ni.
17. Mg-Al.
18. Cd-As.
19. Zn-Pb-Sb.
20. Mn-Cu-Ni.

(Consult "I.C.T."; "Metals Handbook"; abstracting journals.)

Part 7. Physical properties of alloys.

1. Alcumite.
2. Tuf-Stuf.
3. Y-Alloy.
4. Tellurium lead.
5. Illium G.
6. Bain alloy.
7. Armco 13.
8. Oldsmoloy.
9. Herculoy A.
10. 40 Alloy.
11. Tophet A.
12. Alcrosil 5.
13. Silmo.
14. USS 12.
15. Revalon.
16. Everbrite.
17. Red X 10.
18. Nirex.
19. Lo Cro 46.
20. GOHI.

(Consult metallurgical treatises; *Chem. Met. Eng.* statistics.)

Part 8. Corrosion resistance.

1. Ag: cyanogen.
2. Pd: 30% HCl.
3. Ir: H_2SO_4, 250°C.
4. Ru: HNO_3, 120°C.
5. Monel: Conc. HCl.
6. Be: NaOH, aq.
7. Nichrome: NaOH, fused.
8. Cd: acetic acid.
9. Hastelloy: HOBr.
10. Cast iron: H_2S.
11. Ta: HF.
12. Rh: H_2SO_4, 100°C.
13. Os: HNO_3.
14. Au: aqua regia.
15. Pb: dry chlorine.
16. Al: $K_2S_2O_7$, fused.
17. Brass: NH_4OH, aq.
18. Cr: Na_2CO_3, fused.
19. Dow metal: milk.
20. Nitralloy: NaCl, aq.

(Consult works dealing with corrosion.)

Part 9. Current prices.

1. Electrolytic copper.
2. Straits tin.
3. Lead.
4. Zinc.
5. Gold.
6. Silver.
7. Selenium.
8. Mesabi ore.
9. Tungstic oxide.
10. Bauxite.
11. Cadmium.
12. Aluminum.
13. Antimony.
14. Mercury.
15. Platinum.
16. Pig iron.
17. Titanium.
18. Tellurium.
19. Galena ore.
20. Ferrochrome.

(Consult current market reports.)

Assignments for Library Problem 15

Part 1. General information on drugs.

1. Acacia.
2. Calcium lactate.
3. Cinchophen.
4. Elaterin.
5. Eugenol.
6. Apothesine.
7. Guaicol.
8. Kombéin.
9. Ammoniated mercury.
10. Orthoform.
11. Anethole.
12. Cascara sagrada.
13. Colchicine.
14. Eriodictyon.
15. Glycogenal.
16. Hydrastis.
17. Iodol.
18. Lycopodium.
19. Methenamine.
20. Phenetsal.

(Consult "Merck's Index"; Wood and LaWall's "Dispensatory of the U. S."; encyclopedias.)

Part 2. Specifications for drugs and medicinal compounds.

1. Ammonium citrate.
2. Carbon tetrachloride.
3. Dextrose.
4. Ethyl acetate.
5. Hydrogen peroxide.
6. Lead acetate.
7. Potassium iodide.
8. Bismuth subnitrate.
9. Chloroform.
10. Ether.
11. Formaldehyde.
12. Iodine.
13. Magnesium oxide.
14. Silver nitrate.
15. Calcium carbonate.
16. Cupric sulfate.
17. Ethyl bromide.
18. Glycerin.
19. Ferric sulfate.
20. Mercuric iodide.

(Consult "Merck's Index"; Rosin's "Reagent Chemicals and Standards.")

Part 3. Drug manufacturers (or supply houses).

1. Acriflavine.
2. Pepsin.
3. Bone marrow.
4. Pancreas substance.
5. Thymus.
6. Adrenalin.
7. Ginger.
8. Calamine.
9. Terebene.
10. Corpus luteum.
11. Pineal.
12. Diphtheria toxoid.
13. Benzoinol.
14. Nialgen.
15. Hyoscine.
16. Aloe pills.
17. Liver substance.
18. Placenta.
19. Rabies vaccine.
20. Codol.

(Consult works listed in Chap. IX, 2.)

Part 4. Market prices.

1. Castor oil.
2. Codeine.
3. Santonin.
4. Belladonna root.
5. Saffron flowers.
6. Morphine.
7. Cinchona bark.
8. Cream of tartar.
9. Arnica flowers.
10. Benzoin gum.
11. Ergot.
12. Ephedrine.
13. Digitalis.
14. Cassia.
15. Quinine.
16. Camphor gum.
17. Strophanthus seed.
18. Goldenseal root.
19. Manna.
20. Menthol.

(Consult market reports in periodicals.)

Part 5. Composition (preparation) of drugs.

1. Confection of senna.
2. Extract of hydrastis.
3. Glycerite of pepsin.
4. Liniment of opium.
5. Albuminized iron.
6. Ammoniated camphor wash.
7. Carminative mixture.
8. Soft zinc paste.
9. Warburg's pills.
10. Syrup of trifolium.
11. Elixir of aletris.
12. Fluidextract of sarsaparilla.
13. Infusion of rose.
14. Antiseptic solution.
15. Solution of pancreatin.
16. Bismuth magma.
17. Aromatic oil spray.
18. Solid petroxolin.
19. Perfumed spirit.
20. Sweet tincture of rhubarb.

(Consult Am. Pharm. Assoc.'s "National Formulary"; other works listed in Chap. IX, 1.)

Part 6. Methods of analysis (assay, purity tests).

1. Ether.
2. Alum.
3. Citrated caffeine.
4. Chloramine-T.
5. Iron citrate.
6. Magnesium sulfate.
7. Phenol.
8. Ammonium benzoate.
9. Arsphenamine.
10. Calcium gluconate.
11. Cinchona.
12. Mercurous iodide.
13. Nux vomica.
14. Sodium cacodylate.
15. Amyl nitrite.
16. Soluble barbital.
17. Chloral hydrate.
18. Codeine phosphate.
19. Iodophthalein.
20. Oil of clove.

(Consult "Pharmacopoeia of the U. S."; "National Formulary.")

Assignments for Library Problem 16

Information is most easily available for the common chemicals.

1. Aluminum sulfate.
2. Zinc chloride.
3. Copper sulfate.
4. Potassium carbonate.
5. Nitric acid.
6. Chlorine.
7. Mercury.
8. Lead acetate.
9. Sodium nitrate.
10. Silver nitrate.
11. Ethylene.
12. Chloroform.
13. Dextrose.
14. Nitrocellulose.
15. Ethanol.
16. Acetone.
17. Acetaldehyde.
18. Phenol.
19. Ethyl ether.
20. Anthracene.

[Consult appropriate works of reference. See *J. Chem. Education*, **10**, 738 (1933)]

Assignments for Library Problem 17

This problem is devoted to a random selection of miscellaneous items of more or less general interest. Additional items might be selected for those who have time available.

Part 1. Biographical facts concerning chemists.

1. Haber, F.
2. Richards, T. W.
3. Perkin, W. H.
4. Berzelius, J. J.
5. Faraday, M.
6. Van't Hoff, J. H.
7. Ramsay, Wm.
8. Ostwald, W.
9. Pasteur, L.
10. Berthelot, M. P. E.
11. Chandler, C. F.
12. Cannizzaro, S.
13. Lavoisier, A. L.
14. Liebig, J. von.
15. Smith, E. F.
16. Fischer, Emil.
17. Arrhenius, S.
18. Beilstein, F. K.
19. Bunsen, R. W.
20. Mendeléeff, D. I.

[Consult works listed in Chap. IX, 3; abstracting journals; histories of chemistry; Soule, "Library Guide for the Chemist," p. 25 (1937).]

Part 2. Abbreviations used in chemistry.

1. D.R.P.
2. U.dgl.
3. Bl.
4. s.G.
5. E.K.
6. frbl.
7. Pkt.
8. vgl.
9. Ndd.
10. p.d.
11. s.a.
12. mkr.
13. a.a.O.
14. trav.
15. F.
16. Tfl.
17. E.T.Z.
18. Kem.
19. N.T.
20. Cel.

(Consult Crane and Patterson's "Literature of Chemistry.")

Part 3. Summaries of contemporary knowledge.

1. Raman effect.
2. Vitamins.
3. Carbonization of coal.
4. Nitrogen system of compounds.
5. Protective coatings for metals.
6. Plantation rubber.
7. Catalysis in industrial chemistry.
8. Manufacture of sugar.
9. Organic compounds of arsenic.
10. Zinc industry.
11. Constituents of coal tar.
12. Metals of the rare earths.
13. Properties of glass.
14. Enzymes.
15. Vegetable proteins.
16. Photosynthesis.
17. Intermetallic compounds.
18. Alcoholic fermentation.
19. Soluble silicates.
20. Reactions of pure hydrocarbons.

(Consult monographs on chemistry.)

Part 4. Occurrence of chemical substances.

1. Chromium.
2. Mica.
3. Gypsum.
4. Soapstone.
5. Myrtle wax.
6. Fluorspar.
7. Tung oil.
8. Tantalum.
9. Tolu gum.
10. Talc.
11. Pyrite.
12. Monazite.
13. Calcite.
14. Mercury.
15. Asphalt.
16. Cryolite.
17. Asbestos.
18. Magnesite.
19. Feldspar.
20. Tantalite.

(Consult treatises and encyclopedias.)

Part 5. Popular publications (articles and books).

1. Synthetic perfumes.
2. Lacquer solvents.
3. Chemicals from corn.
4. Water purification.
5. Soil-less farming.
6. Artificial leather.
7. Rayon.
8. Rustless steel.
9. Chemistry of sanitation.
10. High-octane gasoline.
11. Color photography.
12. Soybean chemistry.
13. Optical glass.
14. Coal-tar colors.
15. Sulfonated soaps.
16. Gas warfare.
17. Cellophane.
18. Magnesium alloys.
19. Making anesthetics.
20. Packing-house chemistry.

(Consult "Readers' Guide" index; abstracting journals; the less technical periodicals.)

Part 6. Recipes for chemical products.

1. Gold plating.
2. Silvering glass.
3. Orange punch.
4. Indelible ink.
5. Etching glass.
6. Moth repellent.
7. Hardwood filler.
8. Tooth paste.
9. Fireproofing cloth.
10. Liquid glue.
11. Ant insecticide.
12. Grafting wax.
13. Oxidizing silver.
14. Cherry phosphate.
15. Cleaning jewelry.
16. Liquid soap.
17. Perfume.
18. Shoe polish.
19. Disinfectant.
20. Shaving lotion.

(Consult works listed in Chap. IX, 1.)

Part 7. Reactions of inorganic materials.

1. $Cl_2 + TiO_2 + C$.
2. $MgCl_2$ + steam.
3. $NH_4Cl + Na_2B_4O_7$.
4. $CuSCN + KIO_3 + HCl$.
5. $O_2 + CO_2 + H_2O + Zn$.
6. $H_2C_2O_4 + HClO_3$.
7. $CoCl_2 + NH_4OH + H_2O_2$.
8. $NaCl + K_2Cr_2O_7 + H_2SO_4$.
9. $K_4Fe(CN)_6 + K_2S_2O_3$.
10. $U(SO_4)_2 + H_2O + KMnO_4$.
11. Li + propanol.
12. $BaSO_4 + CaCl_2 + C$.
13. $Cu + O_2 + CO_2 + H_2O$.
14. $Au + H^+ + Cl^- + NO_3^-$.
15. Millon's base + ammonia.
16. Leclanché battery constituents.
17. $KI + KBr + KClO_3 + H_2SO$
18. $NaNH_2 + N_2O$.
19. $NaOH + H_2SiF_6$.
20. $PbCrO_4 + KI + HCl$.

(Consult manuals of industrial chemistry and treatises on inorganic chemistry.)

Part 8. Details of experimental methods.

1. Use of glass electrode.
2. Vapor-phase chlorination.
3. Distribution coefficients.
4. Hydrogenation.
5. Electrical conductivity (solns.).
6. Dehydration.
7. Light absorption.
8. Sulfonation.
9. Catalytic activity.
10. Ammonation.
11. Titration with titanous chloride.
12. Liquid-phase nitration.
13. Solubility product.
14. Alkylation.
15. Vapor pressure.
16. Grignard (or other) reaction.
17. Tristimulus values (color).
18. Diazotization.
19. Rate of reaction.
20. Reduction.

(Consult treatises in the appropriate fields.)

Part 9. Methods of preparation.

1. Pure mercury.
2. Catechol.
3. Sulfur dioxide (liq.).
4. Hydroquinone.
5. Magnesium.
6. Dimethylglyoxime.
7. Hydrogen peroxide.
8. Ethylene glycol.
9. Aluminum sulfate.
10. Phosgene.
11. Barium ferrate.
12. Phenylurea.
13. Cuprous chloride.
14. Cupferron.
15. Perchloric acid.
16. *o*-Phenanthroline.
17. Bleaching powder.
18. Cyclopropane.
19. Fluorine.
20. Absolute alcohol.

(Consult treatises in the appropriate fields.)

Assignments for Library Problem 18

Subjects satisfactory for a workable bibliography.

1. Urea-aldehyde resins.
2. Liquid ammonia as a solvent.
3. Ceramic coloring agents.
4. Organosilicon compounds.
5. Uses of soybean oil.
6. Metallic paints.

7. Chemistry of dry cleaning.
8. Photoelectric filter photometers.
9. Metabolic use of bromine.
10. Metallurgy of beryllium.
11. Fluorination of hydrocarbons.
12. Uses of selenium.
13. Synthetic rubber.
14. Spectrographic analysis of minerals.
15. Phosphate water treatment.
16. Antiknock fuels.
17. Platinum substitutes.
18. Rhodium electroplating.
19. Effect of gases on vegetation.
20. Alcohol from agricultural wastes.

(Consult appropriate works of reference, such as treatises, encyclopedias, and monographs; for much bibliographic work, abstracting journals are indispensable.)

Assignments for Library Problem 19

A report covering general information available may be prepared upon almost any chemical subject. However, not all subjects are equally suitable for student use, since beginners lack experience and perspective. Also the material on different subjects varies widely. In general, an assignment that is satisfactory for a bibliography in Problem 18 should be workable for a report. In any case a bibliography forms the basis of a report. For industrial chemistry, assignments such as those in Problem 16 may be desirable.

When one broadens report writing to include the preparation of manuscripts in a form suitable for publication as articles or books, so many details are involved that a weekly problem is insufficient for their consideration. Consequently, the author has expanded Problem 19 into a 1-hour semester's course on technical writing.

APPENDIX

Nonchemical Publications[1]

Among those engaged in the practice of chemistry and chemical technology there is increasing recognition of the value of the great fund of information contained in the chemical literature. Although the contributions to be found in chemical periodicals, institutional publications, patents, and treatises and other books are both fundamental and numerous, these sources are still not sufficient to meet all the technical needs of chemists and chemical engineers. For example, the graduate in chemistry may be confronted with a problem in applied physics (as electricity or optics) or in chemical engineering, while the chemical engineer may well encounter problems requiring information in fields other than his own, even though he has not pursued one of the questionable highly specialized curricula so popular at present. Such varied problems may require diverse kinds of knowledge.

Some individuals, in such situations, may depend upon trained searchers in the larger industrial and technical libraries, or the consultant may well turn to a fellow consultant in another field. Many do not find themselves so fortunately situated and must rely more or less upon their own ingenuity to find what is needed.

Frequently these borderline problems involve some phase of physics, or civil, electrical, or mechanical engineering. The purpose of this section, therefore, is to present a brief outline of certain sources in these fields. In most cases the separate publications included are the selections of individuals working in the respective fields. In general, sources in foreign languages were omitted when suitable ones were available in English, as one in a more or less unfamiliar field may be expected to use first works in his own language.

The nature of the subjects selected is such that the publications fit satisfactorily into the classification used for the general field of chemical literature. In accordance with this scheme, there are indicated in the outline below some of the more important sources of information in physics and certain phases of engineering.

Original Sources

1. Periodicals:

A. Civil Engineering: *Civil Engineering, Engineering, Engineering News-Record, Journal of the American Water Works Association, Proceed-*

[1] Mellon, *J. Chem. Education*, **10**, 619 (1933). See Roberts, "Guide to Technical Literature" (1939), for a more comprehensive treatment of engineering literature.

ings of the American Society for Testing Materials, Sewage Works Journal, Transactions of the American Society of Civil Engineers.

B. Electrical Engineering: *Electrical Engineering, Electrical World, Electronics, General Electric Review, Proceedings of the Institute of Radio Engineers, The Bell System Technical Journal.*

C. Mechanical Engineering: *Aerial Age, Bulletin of the Society of Industrial Engineering, Heating and Ventilating Magazine, Journal of the American Society of Heating and Ventilating Engineers, Journal of the American Society of Automotive Engineers, Mechanical Engineering, Metal Worker, National Engineer, Railway Age, Refrigeration, Transactions of the American Society of Mechanical Engineers.*

D. Mining Engineering: *Engineering Mining Journal, Mining and Metallurgy, Mining Journal, Transactions of the American Institute of Mining and Metallurgical Engineers.*

E. Physics: *Annales de physique, Annalen der Physik* (which appeared at various times as Gilbert's, Poggendorff's, Wiedemann's, and Drude's Annalen), *Journal de physique, Journal of Applied Physics, Journal of the Optical Society of America, Review of Scientific Instruments, Physics, Physical Review, Proceedings of the Physical Society, Physikalische Zeitschrift, Zeitschrift für Physik.*

2. Institutional Publications.—Certain governmental bulletins cover technical research along scientific lines which are applicable to various fields of engineering. Valuable contributions come from the U. S. Bureau of Mines, the National Bureau of Standards, and various state engineering experiment stations. Lists of such publications may be secured from the directors of these laboratories.

3. Patents.—The general nature of the information to be found in patents is the same for the fields considered here as for chemistry and chemical technology. There appears to be no place, such as *Chemical Abstracts*, where it is gathered together for ready reference. The *Official Gazette of the U. S. Patent Office*, with its several indexes, is probably the best source for domestic patents. Some technical periodicals carry notices or brief digests of the more significant patents in specialized fields.

4. Miscellaneous Publications.—Manufacturers' technical bulletins, circulars, and pamphlets are very numerous in engineering fields. They deal with problems of the users of apparatus, describe new machinery and appliances, and discuss the technical problems of the manufacture, testing, and application of equipment and related items. The publications are procurable from the manufacturers. Except in the field of physics, there are few doctoral dissertations.

Secondary Sources

1. Periodicals:

a. Index Serials.—Occasionally publications may be located through their titles by referring to such index serials as the following:

1. *Engineering Index* (1890+).—It covers references of a technical and commercial nature, including material dealing with costs, finance, and management of industrial concerns. This appears annually and is a title index.
2. *Industrial Arts Index* (1913+).—This is an index of general technical articles, including new apparatus and machinery.
3. "*Repertorium der technischen Journal-literatur*" (1823–1908).—From the standpoint of time covered, this is an important foreign serial.
4. "*Technical Supplement to the Daily Review of the Foreign Press.*"—Notices are included for certain material appearing in foreign journals on civil, electrical, and mechanical engineering.

b. Abstracting Journals.—The following sources are available: *Science Abstracts*, with Section A devoted to physics and Section B to electrical engineering; a number of specialized periodicals (original sources) which contain sections devoted to abstracts; and the *Engineering Index Service.*

Strictly, the last publication is not a printed periodical, but it functions as such. Over 2000 technical, scientific, and industrial periodicals are searched at the Engineering Societies Library (29 W. 39th St., New York City). For each contribution a card (3 by 5 in.) is prepared, the accompanying reprint being a representative example.

PLASTICS

Molding

Molding Plastics by Injection Method, H. Chase. Machy (NY) v 44 n 5 Jan 1938 p 310–3.

High molding speeds and products of intricate design are results obtained by injection molding process similar to die casting; plastic molding methods described are employed at plant of Erie Resistor Corp, Erie, Pa; machines are of injection type; illustrations given.

157 No. 38—551

Printed in U. S. A. Engineering Index Service

The material is classified into some 300 divisions, and the cards are mailed weekly to subscribers, who may take any or all the divisions. Divisions 28, 29, and 30 cover chemical engineering, chemicals, and chemistry, respectively, although about 20 per cent of the total number deal with some phase of applied chemistry.

2. Bibliographies.—Bibliographies in these fields are widely scattered, but they appear most often in connection with some other publication. They do not differ in nature from those in chemistry. No general reference source for them is available. Darrow's "Classified List of Published Bibliographies in Physics" (1910–1922) is an example of a comprehensive effort in this direction.

3. General Works of Reference and Textbooks:

A. Reference Works:

1. *Tabular compilations.*—For the chemist this type of publication is probably as important as any mentioned here. Some of those more or less commonly used are listed below.
   - *a. Civil Engineering:* Blanchard, "American Highway Engineers' Handbook," Hool, "Concrete Engineers' Handbook"; Hool and Johnson, "Handbook of Building Construction"; Ketchum, "Structural Engineer's Handbook"; Kidder and Parker, "Architects and Builders' Handbook"; Merriman, "American Civil Engineers' Handbook"; Trautwine, "Civil Engineers' Reference Book"; Urquhart, "Civil Engineering Handbook."
   - *b. Electrical Engineering:* Abbott, "National Electrical Code Handbook"; Croft, "Practical Electric Illumination and Signal-Wiring Methods"; Fowle, "Standard Handbook for Electrical Engineers"; Pender and McIllwain, "Electrical Engineers' Handbook—Communication and Electronics"; Pender and DelMar, "Electrical Engineers' Handbook—Electric Power."
   - *c. Mechanical Engineering:* Am. Soc. Mech. Eng., "Refrigerating Data Book"; Colvin and Stanley, "American Machinists' Handbook"; Hoffman, "Handbook for Heating and Ventilating Engineers"; Kent, "Mechanical Engineers' Handbook"; Marks, "Mechanical Engineers' Handbook"; Oberg and Jones, "Machinery's Handbook"; "S.A.E. Handbook"; Siebel, "Compend of Mechanical Refrigeration"; Tulley, "Engineer's Handbook"; Walker and Crocker, "Machinery's Handbook" and "Piping Handbook"; Willard and Harding, "Heating and Ventilating" and "Power Plants and Refrigeration."
   - *d. Mining Engineering:* Battle, "Industrial Oil Engineering"; Peele, "Mining Engineers' Handbook"; Taggart, "Handbook of Ore Dressing."
   - *e. General:* Eschbach, "Handbook of Engineering Fundamentals"; Hudson, "The Engineer's Manual"; O'Rourke, "General Engineering Handbook"; Washburn, "International Critical Tables."
2. *Treatises.*—Encyclopedic treatises are less common in engineering than in chemistry. The following examples may be of occasional value to the chemist:

a. Electrical Engineering: "Cyclopedia of Applied Electricity" (8 v.).

b. Mechanical Engineering: "Henley's Encyclopedia of Practical Engineering" (5 v.).

c. Physics: Born and Franck, "Struktur und Eigenschaften der Materie," (18 v.); Eucken and Wolf, "Hand- und Jahrbuch der chemischen Physik," (10+v.); Geiger and Scheel, "Handbuch der Physik" (24 v.); Glazebrook, "Dictionary of Applied Physics" (5 v.); Masing, "Handbuch der Metall-Physik" (4 v.); Müller-Pouillets, "Lehrbuch der Physik" (5 v. in 13 pts.); Wien-Harms, "Handbuch der Experimental-physik" (26 v. in 43 pts.).

d. General: "Cyclopedia of Engineering" (7 v.); Industrial Press, "Encyclopedia of Engineering" (1 v.), and "Machinery's Encyclopedia" (7 v.), Lueger, "Lexikon der gesamte Technik" (7 v.).

3. *Monographs.*—When competently written, monographs are likely to be the most reliable of the reference works whose data are affected by the time lag so frequently encountered in the literature of a rapidly changing field. As far as the writer is aware, there is no general list of monographs for the fields considered here.

B. Textbooks.—There are many textbooks covering various phases of engineering and physics. Much of the information contained therein is undoubtedly reliable, but it seems quite probable that one should maintain toward them the same skepticism that is necessary in using textbooks in chemistry.

For the available textbooks and monographs in engineering and physics, suggestions may be obtained from the shelf lists of technical libraries and from publishers' catalogues. In the engineering fields there is the possibility of taking advantage of the excellent facilities of the Engineering Societies Library, either to visit it or to inquire about publications. Also the *Technical Book Review Index* may be of value.

4. Miscellaneous Sources.—In engineering one may expect to find the same kind of biographical and guidebook literature as those listed in Chap. IX, 2, 3.

INDEX

"Of many large volumes, the index is the best portion and the most useful.
—WILMOTT.

[1] In this combined author, subject, and title index the subject headings are most numerous, entries being included for all items considered necessary for efficient use of the book. Whenever a publication is well known by the name of its author, this name is included. Most names were omitted for the footnote references, for several separate lists of references, and for the lists of monographs and textbooks. Specific titles are included only for certain publications known especially by their titles (not including journals). Other items are referred to by general headings.